

SECTION 5

HYDRAULIC DISCHARGE MEASUREMENTS ON THE DETROIT RIVER

5.1 Fort Wayne Section, 1901-1902.

5.1.1 Purpose.

The first recorded discharge measurements conducted on the Detroit River were made at the Fort Wayne Section. These measurements were made in conjunction with the development of stage-discharge relationships for the Detroit River. The measurements were carried out by the U.S. Lake Survey District, Corps of Engineers, in 1901 and 1902.

5.1.2 Description of Section.

The Fort Wayne Section was first established for this survey. It was located on the Detroit River adjacent to historical Fort Wayne in Detroit, Michigan, and traversed the river to Windsor, Ontario. The section was divided into 20 panels. Fifty-six discharge measurements were made at this section, between July 19 and December 10, 1901. In 1902, 61 measurements were made between June 25 and November 20.

The location of this discharge measurement section is shown on Figure 5-1.

5.1.3 Measurement Techniques.

The section was sounded in both 1901 and 1902. Vertical velocity measurements were made during both measurement periods, but only at selected depths. The vertical velocity measurements made in 1901 were at three to seven points in the vertical. The 1902 vertical velocity measurements were at only two points in the vertical.

Two velocity meters were used simultaneously to measure the discharge of each panel. Velocities were measured at the 0.3 and 0.7 depths and twice at the 0.5 depth, during each measurement. For reference, water levels were recorded at the Windmill Point, Fort Wayne and Amherstburg gauges.

5.1.4 Discharge Computation.

Panel areas were determined for both series of measurements using soundings made at that time. From the vertical velocity measurements, vertical velocity coefficients were determined for each panel. These coefficients related the velocities measured at the 0.3, 0.5 and 0.7 depths to the velocity in the panel. Transverse velocity curves were developed.

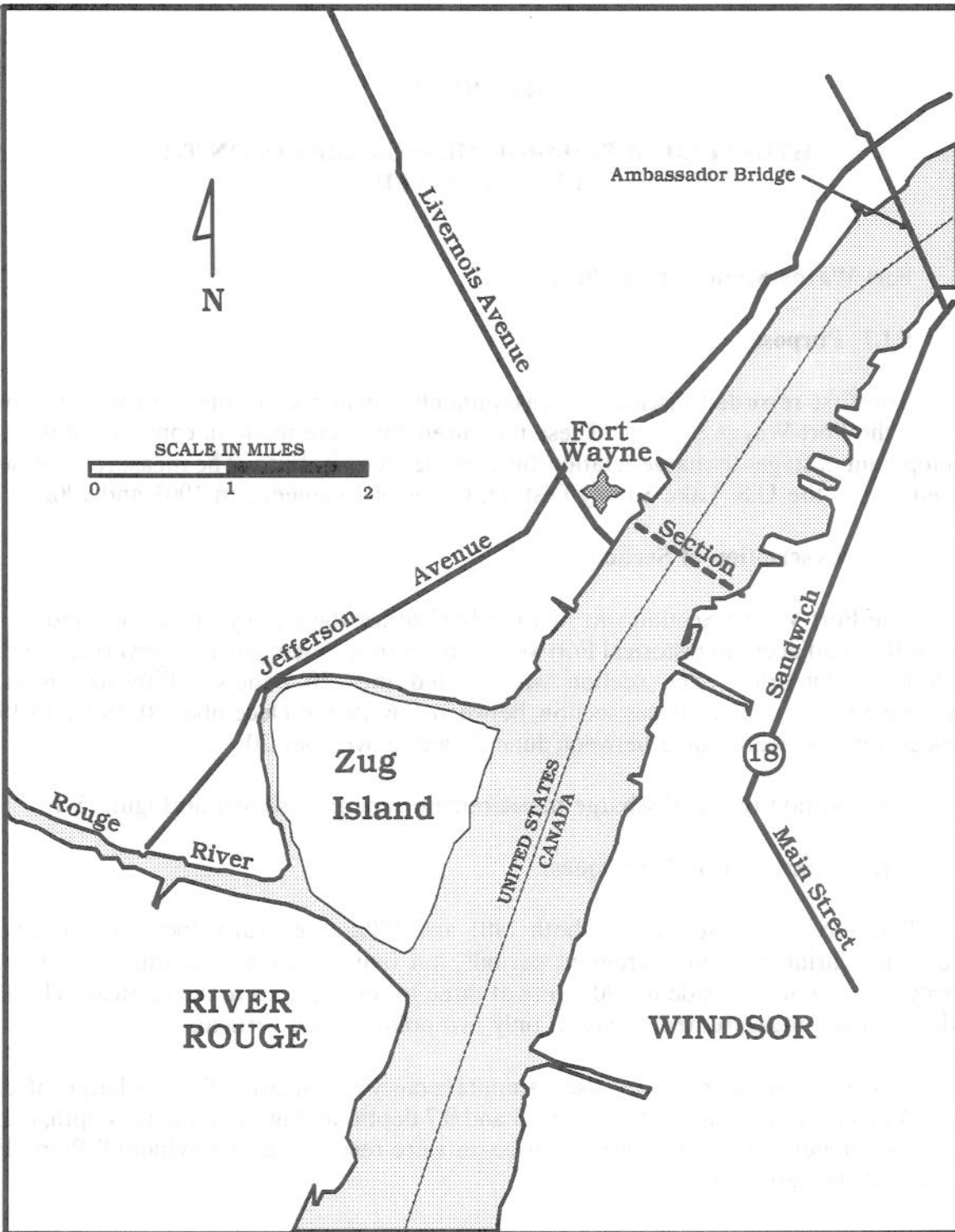


Figure 5-1

Detroit River, Fort Wayne Section Location

Using vertical velocity, transverse coefficients and the areas of the panels, discharges were computed for each panel for each depth metered (0.3, 0.5 and 0.7 depths). All the panel discharges computed for a particular depth were added to obtain a discharge through the section as measured at that depth. The section discharges computed for the 0.3, 0.5 and 0.7 depths were averaged to obtain the discharge through the section for that measurement.

Information on these measurements can be found in the U.S. Lake Survey Archives, files 3-1499, 3-1500, 3-1501, 3-1502, 3-1503 and 3-1573 (available at the U.S. National Oceanic and Atmospheric Administration/National Ocean Service, Silver Springs, Maryland). Limited information pertaining to these measurements may also be found in file 3-1574 of the Great Lakes Hydraulics and Hydrology Branch Archives of the Detroit District, Corps of Engineers, Detroit, Michigan. A summary of the 1901 and 1902 discharge measurements is given in Tables 5.1 and 5.2 (see Appendix C).

5.2 Trenton Channel, 1912-1925.

Records imply that discharge measurements were made in the Trenton Channel in 1912, 1922, 1923, 1924 and 1925. The only evidence found on these measurements is a summary table in the U.S. Lake Survey Archives, file 3-2606, available at the U.S. National Oceanic and Atmospheric Administration/National Ocean Service, Silver Springs, Maryland. Measurements are also mentioned in file 3-2940. No descriptions of the section or of the methods used to measure and reduce the discharges were found. Table 5.3 is a summary of these measurements (see Appendix C). The location of the Trenton Channel is shown on Figures 2-10 and 5-2.

5.3 Fort Wayne Section, 1928-1937.

5.3.1 Purpose.

Discharge measurements were made at the Fort Wayne Section, in 1928 and 1930, to gather additional base data for the continual development of stage-discharge relationships. The 1930 measurements were also part of a measurement program to determine the distribution of flow through the channels in the lower Detroit River (see Subsection 5.4). Measurements were again made at this section in 1933 and 1937 (see Subsections 5.5 and 5.7, respectively), during programs to measure the distribution of flow as changes were being made in the lower river as part of a 24-foot navigation project. In 1933, a cofferdam was built in the lower river for the first phase of the widening and deepening of the Livingstone Channel. The measurements in 1937 were made after the project was completed and were used to determine a new stage-discharge relationship for the new regimen.

5.3.2 Description of Section.

The Fort Wayne Section was reestablished from the survey made in 1901 and 1902. Located adjacent to historic Fort Wayne in Detroit, Michigan, the section crossed the river to Windsor, Ontario. The section was approximately 2,200 feet wide and was divided into 20 panels. Ten discharge measurements were made between September 14 and September 20, 1928 and 18 measurements were made during the period July 19 through July 30, 1930. In 1933, a series of 15 measurements were made during the period September 12 through September 27. Twenty-five discharge measurements were made between June 29 and July 19, 1937.

The location of this discharge measurement section is shown on Figure 5-1.

5.3.3 Measurement Techniques.

The section was sounded in 1928, 1930, 1933 and 1937. Vertical velocity measurements were made in 1928. The discharge measurements were made using three current meters suspended at the mid-depth (0.5 depth) of the panel, simultaneously.

Water levels were recorded at the Windmill Point, Fort Wayne and Wyandotte gauges. The Windmill Point gauge was a staff gauge located on the old lighthouse dock near the foot of Alter Road in Detroit, Michigan. The gauge was referenced to bench mark "W" at elevation 582.76 feet on the 1903 Datum (580.92 feet IGLD 1955). The Fort Wayne gauge was located at the north end of the Fort Wayne Reservation, at the foot of Livernois Avenue in Detroit, Michigan. This gauge, at the time of these measurements, was referenced to bench marks that no longer exist. The Wyandotte gauge used in 1933 was installed at the foot of Orange Street in Wyandotte, Michigan. This gauge was referenced to bench mark Harbor Line Mon. 90 at elevation 578.08 feet on the 1903 Datum (576.18 feet IGLD 1955).

5.3.4 Discharge Computation.

Panel areas were determined in both 1928 and 1930, based upon the soundings made at that time. The same 15 panel positions were used in both determinations, but different panel areas were used in the reduction of discharges for the two years. Small discrepancies in the soundings of 1933 indicated shoaling. This shoaling was much more pronounced in the 1937 soundings. Despite this shoaling, the panel areas determined in 1930 were used to compute discharges in 1933 and 1937, except that in 1937, when the areas were corrected slightly for the shoaling.

In 1928, transverse velocity coefficients were determined for the two panels on each end of the section. Vertical velocity coefficients for each panel were also determined in

1928. These coefficients were used to reduce the 1928, 1930, 1933 and 1937 measurements. However, in 1933 and 1937 slight modifications were made to the transverse curve in the end panels.

The velocity measured at the 0.5 depth of a panel was multiplied by the appropriate coefficients and by the panel area to get the discharge through that panel, as measured by a particular meter. The discharges measured at all panels, by a particular meter, for a particular measurement, were summed to get the discharge through the section, as measured by that meter. The section discharge, as measured by each of the three meters, was averaged to give the discharge through the section for that measurement.

The 1928 and 1930 discharge measurements are documented in file 3-2548 of the Great Lakes Hydraulics and Hydrology Branch Archives of the Detroit District, Corps of Engineers, Detroit, Michigan. Information on the 1933 measurements can be found in file 3-2683. File 3-2939 contains the documentation of the 1937 measurements. The discharges are summarized in Tables 5.4 through 5.7 (see Appendix C).

5.4 Lower Detroit River, 1930.

5.4.1 Purpose.

The distribution of flow in the lower Detroit River was first measured in 1930, prior to the deepening of the channels for the 24-foot navigation project. All measurements were made by the U.S. Lake Survey District, Corps of Engineers.

5.4.2 Description of Sections.

The **Trenton Channel Section** was established for this measurement program. It was located about 1,500 feet below the foot of Orange Street in Wyandotte, Michigan. The section was divided into 7 panels. A series of six discharge measurements were made during the period July 12-15, 1930.

The **Stony Island Section** was established across the Stony Island Channel, between Grosse Ile and Stony Island. The section was approximately 1,350 feet wide and was divided into ten panels. Six discharge measurements were made between June 19 and July 11, 1930.

The **Limekiln Crossing Section** extended across the Ballards Reef Channel from a cofferdam to the Canadian shore. The section was divided into 12 panels. A total of six discharge measurements were made between June 5 and July 10, 1930.

The **Dry Cut Section** was established across the Livingstone Channel, between cofferdams, situated below Stony Island. The section was divided into six panels for this series of measurements. Nine discharge measurements were made between May 26 and July 9, 1930.

Discharge measurements were also made at the **Fort Wayne Section**, in 1930. These measurements are documented in Subsection 5.3.

The approximate locations of these discharge measurement sections are shown on Figure 5-2.

5.4.3 Measurement Techniques.

Soundings and vertical velocity measurements were made at all the sections. Vertical velocity measurements consisted of readings at different combinations of odd or even tenth depths. Velocity measurements for the computation of discharges were made only at the 0.5 depth, using three current meters recording simultaneously.

Water levels were recorded at the following gauges:

<u>Water Level Gauge</u>	<u>Controlling Bench Mark</u>	<u>Bench Mark Elevations (feet) 1903 Datum</u>
Fort Wayne	Warehouse	582.32
Wyandotte	Orange	577.88
Amherstburg	---	---
Gibraltar	Gibraltar No.1	587.61
Ouellette	Windmill	582.42
Wigle	Wigle 1930	581.06

5.4.4 Discharge Computation.

From the soundings, panel areas for each of the sections were determined. From the vertical velocity measurements, vertical velocity coefficients were determined, to relate the 0.5 depth velocity readings to the velocity in the vertical plane of a panel. From the velocity measurements at the 0.5 depth of each panel in a section, transverse velocity curves were drawn and coefficients determined.

For each velocity reading at the 0.5 depth of a panel, the discharge was computed by applying the appropriate vertical and transverse velocity coefficients and panel areas. The discharges measured by a particular meter were summed across the section. The section discharges, as measured by each of the three meters, were averaged to get the discharge through the section for a particular measurement.

Information on this survey can be found in file 3-2606 of the U.S. Lake Survey Archives (available at the U.S. National Oceanic and Atmospheric Administration/National Ocean Service, Silver Springs, Maryland). Tables 5.8 to 5.11 (see Appendix C) summarize these measurements.

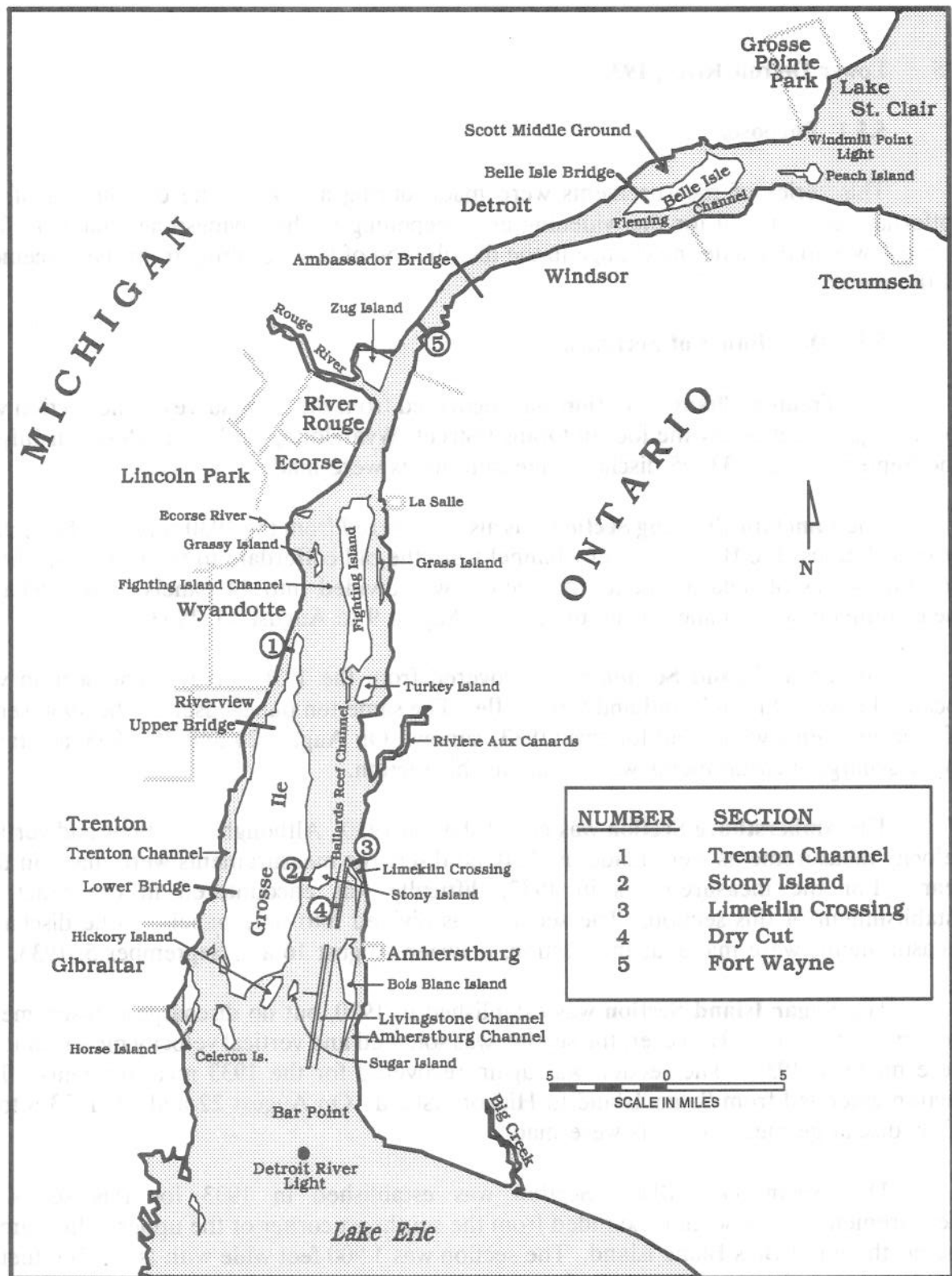


Figure 5-2

Lower Detroit River, 1930 Section Locations

5.5 Lower Detroit River, 1933.

5.5.1 Purpose.

This series of measurements were made during and after the completion of the cofferdam constructed for the widening and deepening of the Livingstone Channel. The purpose was to evaluate the change in the distribution of flow resulting from the placement of the cofferdam.

5.5.2 Description of Sections.

The **Trenton Channel Section** was recovered from the 1930 survey. The section was located 1,500 feet below the foot of Orange Street, Wyandotte, Michigan. Between July 19 and September 9, 1933, 25 discharge measurements were made.

The **Limekiln Crossing Section** was also recovered from the 1930 survey. The section extended across the Ballards Reef Channel from the old cofferdam to the Canadian shore. For this series of measurements the section was divided into 14 panels. Six discharge measurements were made during the period August 9 to August 15, 1933.

The **Stony Island Section** was recovered from the 1930 survey. The section was located between Stony Island and Grosse Ile. The same ten panels used in the 1930 series of measurements were used for this (1933) survey. On August 24 and 25, 1933, a total of five discharge measurements were made at this section.

The **Amherstburg Section** was established in 1930. Although soundings and vertical velocity measurements were made in 1930, no discharge measurements were made in that year. For the measurements in 1933, difficulty was encountered in the exact re-establishment of this section. The section was divided into nine panels. Nine discharge measurements were made, at this section, between August 16 and September 5, 1933.

The **Sugar Island Section** was established in 1930, but no discharge measurements were made that year. However, the section was sounded and vertical velocity measurements were made in 1930. The section was again recovered for the 1933 measurements. The section extended from Sugar Island to Hickory Island. On August 22 and 23, 1933 a total of six discharge measurements were made.

The **North Bois Blanc Section** was established in 1933 for this series of measurements. This section extended from the southeast corner of the upper cofferdam to the north end of Bois Blanc Island. The section was 1,900 feet wide with about 500 feet of shoal water at the southeast end. It was divided into 12 panels, three of which were in shallow water. Eight discharge measurements were made between August 26 and September 1, 1933.

Discharge measurements were also made at the **Fort Wayne Section**, in 1933. These are documented in Subsection 5.3.

The approximate locations of these discharge measurement sections are shown on Figure 5.3.

5.5.3 Measurement Techniques.

Soundings and vertical velocity measurements were made at all the sections. A direction of flow survey was made at the Limekiln Crossing Section to determine direction coefficients. Velocity measurements for the computation of discharges were made at the 0.5 depth, using three current meters recording simultaneously. Current meters used included Haskell, Hoff and Gettner meters.

Water levels were recorded at eight gauges: Windmill Point, Fort Wayne, Ouellette, Wyandotte, Wigle, Gibraltar, Lower Dike and Stony Island. The Windmill Point gauge was located near the head of the Detroit River at the foot of Alter Road in Detroit, Michigan. The Fort Wayne gauge was located on the Corps of Engineers slip at the foot of Livernois Avenue, Detroit, Michigan. The Ouellette gauge was located at the Ouellette Boathouse in Windsor, Ontario. The Wyandotte gauge was located at the foot of Orange Street, Wyandotte, Michigan. The Wigle gauge was located at Amherstburg, Ontario. The Gibraltar gauge was installed on the north face of Hall's Dock at the foot of Grandview Avenue, Gibraltar, Michigan. Lower Dike was a gauge on the west side of the west Livingstone Channel dike, about 75 feet north of the south end of the dike. The Stony Island gauge was located 21 feet north of the northwest corner of an old bridge abutment on Stony Island.

The following is a list of the bench marks to which the water level gauges were referenced and the elevations of these bench marks.

<u>Water Level Gauge</u>	<u>Controlling Bench Mark</u>	<u>Bench Mark Elevation (feet) 1903 Datum</u>
Windmill Pt.	W	582.76
Fort Wayne	Warehouse	582.32
Ouellette	Windmill	582.42
Wyandotte	Orange	577.88
Gibraltar	Gibraltar No.1	587.61
Wigle	Wigle 1930	581.06
Lower Dike	South Dike	579.87
Stony Island	Stony	579.64



Figure 5-3

Lower Detroit River, 1933 Section Locations

5.5.4 Discharge Computation.

The panel areas were redetermined for all sections, using soundings made in 1933. New transverse velocity coefficients were also determined for each section. For the Trenton Channel Section, vertical velocity coefficients were determined from observations made in both 1930 and 1933. Using these new coefficients and 1933 panel areas, the 1930 discharges were recomputed (see Table 5.8 of Appendix C). Vertical velocity coefficients for the Limekiln Crossing Section were computed, using observations from 1930 and 1933, except in panels 1, 12, 13 and 14, where the coefficients of 1930 were used. For the Amherstburg Section, vertical velocity coefficients were determined, using 1930 and 1933 data, except in panels 1 and 9, where only observations from 1933 were used. The vertical velocity coefficients for panels 4 and 6 of the Sugar Island Section were those determined in 1930. Vertical velocity coefficients were recomputed for the remaining panels of this section, using observations from both 1930 and 1933. For the Stony Island Section, the vertical velocity coefficients determined in 1930 were used. The vertical velocity coefficients at the North Bois Blanc Section were determined from the measurements of 1933.

For each velocity reading at the 0.5 depth of a panel, a discharge was computed by applying the appropriate vertical and transverse velocity coefficients and panel areas. The discharges measured by a particular meter were summed across the section. The section discharges, as measured by each of the three meters, were averaged to get the discharge through the section for a particular measurement.

Information on this survey can be found in file 3-2683 of the Great Lakes Hydraulics and Hydrology Branch Archives of the Detroit District, Corps of Engineers, Detroit, Michigan. Tables 5.12 to 5.17 (see Appendix C) summarize these measurements.

5.6 Fighting Island and Grass Island Sections, 1934.

5.6.1 Purpose.

These discharge measurements were made by the U.S. Lake Survey District, Corps of Engineers, to measure the distribution of flow east of Fighting Island.

5.6.2 Description of Sections.

The **Fighting Island Section** consisted of two section lines, both crossing the Fighting Island Channel above Grassy Island. The section lines were both 680 feet wide. The measurement of flow at this section was made between 8:46 AM and 10:26 AM (EST) on July 20, 1934. For the computation of discharge, the section was divided into six panels.

The **Grass Island Section** also consisted of two section lines. These lines extended from Grass Island to the Canadian mainland at LaSalle, Ontario. The section lines were approximately 400 feet wide, with an area of weed growth near the shore. Measurements

at this section were made between 10:56 AM and 11:28 AM, July 20, 1934. For the computation of discharge, the section was divided into five panels. The end panels did not include areas of weed growth.

The historic data reviewed did not include a sketch that showed the location of these sections. However, with the above description and referring to Figure 5-3, the approximate location of these sections can be surmised.

5.6.3 Measurement Techniques.

Soundings were made at the upper and lower section lines of each section. The measurements of current velocity were obtained by timing floats between the two section lines. The floats were submerged 6.8 feet below the surface of the water. At the Fighting Island Section, a series of ten float runs were made at various points along the section. At the Grass Island Section, seven float runs were made.

5.6.4 Discharge Computation.

The same method was used to compute the discharge through both the Fighting Island and the Grass Island Sections.

A mean section was determined by averaging the soundings at the upper and lower section lines of the section. Panels were determined on this mean section and the position of each float run was marked.

Each velocity measured at 6.8 feet from the surface was converted to the velocity at 0.4 of the depth, using a vertical velocity curve derived in the late 1920s for the Woodtick Section on the St. Clair River. A transverse velocity curve was drawn from the derived velocities for the 0.4 depth.

The velocity, every ten feet along a panel, was determined using whatever velocity was measured in the panel (converted to the 0.4 depth) and the transverse velocity curve for the section. The average depth in a panel was multiplied by the width of that panel and that in turn was multiplied by the average of the velocities determined for every ten feet of the panel. This gave the mean discharge in the panel. The mean panel discharges were added to get a section discharge. The results of these computations gave a flow of 23,262 cfs at the Fighting Island Section and a flow of 10,820 cfs at the Grass Island Section.

The data from this set of measurements can be found in file 3-2816 of the U.S. Lake Survey Archives (available at the U.S. National Oceanic and Atmospheric Administration/National Ocean Service, Silver Springs, Maryland).

5.7 Belle Isle Section and Lower Detroit River, 1937.

5.7.1 Purpose.

The U.S. Lake Survey District of the Corps of Engineers conducted this series of measurements to assess the distribution of flow in the upper and lower Detroit River, following the widening and deepening of the river for the 24-foot navigation project.

5.7.2 Description of Sections.

The **Belle Isle Section** was established in 1937, specifically for this series of measurements. The section was located about 900 feet below the head of Belle Isle, across the American Channel. It extended across the river from the Edison Boat Club to Belle Isle, positioned normal to the line of flow. The section was divided into 7 panels, but because of the shallow depths (less than 5 feet) in panels 6 and 7, near the mainland, discharge was measured only in panels 1-5. Ten discharge measurements were made between September 17 and September 23, 1937. Water was being taken out of the river, above the section, by the Detroit Water Board and the Connor Creek Edison plant. Domestic pumpage, for the days discharge measurements were being made, averaged about 440 cfs (September 17), 444 cfs (September 20) and 432 cfs (September 23). A constant of 268 cfs was assumed for water diverted through the Edison plant.

The **Stony Island Section** was recovered from past surveys (1930, 1933). The section, located between Stony Island and Grosse Ile, was divided into ten panels. During the period August 6 to August 10, 1937, ten discharge measurements were made at this section.

The **Dry Cut Section** was recovered from the 1930 survey. This section was located across the Livingstone Channel, between the dikes, below Stony Island. The section was split into six panels for measurement and reduction of discharge. Ten discharge measurements were made between August 11 and August 17, 1937.

The **Limekiln Crossing Section** was first established in 1930. Discharge measurements were made at this section in 1933 and for these measurements. The section extended across the Ballards Reef Channel from near the northern end of the Livingstone Channel dike to the Canadian mainland. For this series of measurements, the section was divided into ten panels. Between July 29 and August 4, 1937, ten discharge measurements were made.

The **Trenton Channel Section** was established in 1930 and recovered in 1933, and again for these measurements. The section was located about 1,500 feet below the foot of Orange Street, Wyandotte, Michigan, and extended from the U.S. mainland to Grosse Ile. The section was divided into seven panels. Between July 22 and July 27, 1937, a series of 14 discharge measurements were made at this section.

The **Sugar Island Section** was established in 1930, but no discharge measurements were made that year. The section, which was recovered in 1933, and again for these measurements, was located between Sugar Island and Hickory Island. For this series of measurements the section was divided into six panels. Eleven discharge measurements were made during the period August 18 to August 21, 1937.

The **Sugar Island Dike Section** was established for this series of measurements. This section stretched from Sugar Island to the Sugar Island dike, which extends west from the Livingstone Channel dike. The section, only about 350 feet wide, was divided into three panels. During September 3 and 4, 1937, 13 discharge measurements were made.

The **Lower Cut Section** was established in 1930. Discharge measurements were not made that year; however, the section was sounded and vertical velocity measurements were made. Recovered for this survey, the section was located between the dikes of the Livingstone Channel, adjacent to Bois Blanc Island and was divided into five panels. Ten discharge measurements were made, at this section, between August 23 and August 25, 1937.

The **Bois Blanc Dike Section** was established for this series of measurements. The section was 400 feet wide and extended east/west from Bois Blanc Island to the Livingstone Channel dike, about 980 feet north of the Lower Cut Section. The section was divided into three panels. Nine discharge measurements were made between September 8 and September 9, 1937.

The **Amherstburg Channel Section** was established in 1930, but discharge measurements were not made at the section until 1933. The section, as recovered from the 1933 survey, was located across the Amherstburg Channel and extended from the Canadian mainland near Amherstburg, Ontario, to Bois Blanc Island. The section consisted of nine panels. Thirteen discharge measurements were made between August 27 and September 2, 1937.

Discharge measurements were also made at the **Fort Wayne Section** in 1937. These are documented in Subsection 5.3.

The approximate locations of these discharge measurement sections are shown on Figure 5-4.

5.7.3 Measurement Techniques.

All sections were sounded. Vertical velocity measurements were made in all panels of the Sugar Island Dike and Bois Blanc Dike Sections and in selected panels of the Dry Cut (panels 2,3,5), Limekiln Crossing (panels 8,9), Trenton Channel (panels 1-3) and Lower Cut (panels 4,5) Sections. These measurements were made at the surface, bottom and every odd tenth depth (0.1, 0.3, 0.5, 0.7, 0.9) using two velocity meters, simultaneously. No vertical velocity measurements were made in 1937 at the Stony Island, Sugar Island or Amherstburg



Figure 5-4

Belle Isle and Lower Detroit River, 1937 Section Locations

Channel Sections. Discharge measurements were made using three velocity meters suspended at the 0.5 panel depth, simultaneously.

Water levels were recorded at the following gauges: Windmill Point, Fort Wayne, Wyandotte, Ouellette and Wigle gauges. See Section 5.5.3 (1933 measurements in the lower Detroit River) for gauge location and controlling bench marks.

5.7.4 Discharge Computation.

At the Belle Isle, Limekiln Crossing (panel 10 only), Dry Cut, Sugar Island Dike, Lower Cut and Bois Blanc Dike Sections, the panel areas used to compute discharges were determined entirely from the 1937 soundings. Panel areas determined in 1933 were used at the Limekiln Crossing (panels 1-9), Sugar Island and Amherstburg Channel Sections. The panel areas used at the Stony Island Section were an average of the panel areas determined in 1933 and 1937. At the Trenton Channel Section, the panel areas were an average of areas determined in 1930, 1933 and 1937.

The vertical velocity coefficients, used at each section, were determined from plots of vertical velocity measurements, while the transverse velocity coefficients were determined from plots of the average velocity measured at points across the section. The coefficients for each section were derived from data gathered in the years indicated in tabulations below:

<u>Section</u>	<u>Vertical</u>	<u>Transverse</u>
Belle Isle	1937	1937
Stony Island	1933	1933 panels 1-9 1937 panel 10
Dry Cut	1933 panels 1,4,6 adj.* 1937 panels 2,3,5	1937
Limekiln Crossing	1930 panel 1 1933 panels 2-9 1937 panel 10	1933 panels 2-9 1937 panels 1,10
Trenton Channel	1933 panels 4-7 1937 panels 1-3	1933 panels 2-6 1937 panels 1,2,7
Sugar Island	1933	1937
Sugar Island Dike	1937	1937
Lower Cut	1930 panels 1-3 1937 panels 4,5	1937
Bois Blanc Dike	1937	1937
Amherstburg Channel	1933	1933

*Coefficients computed in 1933 were adjusted by the difference found between the 1933 and 1937 coefficients at panels 2, 3 and 5.

Direction of flow coefficients were determined, in 1937, for the Belle Isle and Sugar Island Dike Sections. Direction of flow coefficients determined in 1933 were used for the Limekiln Crossing Section.

Discharge measurements at all the sections were computed in a similar manner. The velocity measured at the 0.5 depth of a panel was multiplied by the appropriate coefficients and by the panel area to get the discharge through that panel, as measured by a particular meter. The discharge measured at all the panels, by a particular meter, for a particular measurement, were summed to get the discharge through the section, as measured by that meter. The section discharges, as measured by each of the three meters, were averaged to give the discharge through the section for that measurement.

Information on the measurements at the Belle Isle Section can be found in file 3-2939 of the U.S. Lake Survey Archives (available at the U.S. National Oceanic and Atmospheric Administration/National Ocean Service, Silver Springs, Maryland). Data from the measurements at the Stony Island, Dry Cut, Limekiln Crossing and Trenton Channel Sections are located in file 3-2940. Data from the measurements at the Sugar Island, Sugar Island Dike, Lower Cut, Bois Blanc Dike and Amherstburg Channel Sections are in file 3-2941. The discharge measurements documented in this section are summarized in Tables 5.18 to 5.27 (see Appendix C).

5.8 Trenton Channel Section, 1941.

5.8.1 Purpose.

Discharge measurements were made at the Trenton Channel Section by the U.S. Lake Survey District, Corps of Engineers, to determine the effect on flow capacity of channel dredging completed in 1940. Improvements for navigation, as far down as the turning basin below the County Bridge, was completed in July 1940.

5.8.2 Description of Section.

The Trenton Channel Section, established in 1930, was re-established. Located about 1,500 feet below the foot of Orange Street in Wyandotte, Michigan, the section extended from the U.S. mainland to Grosse Ile. Twenty discharge measurements were made between May 17 and May 23, 1941.

The approximate location of this discharge measurement section is shown on Figure 5-4.

5.8.3 Measurement Techniques.

The section was sounded. Discharge measurements were made simultaneously in each panel using three velocity meters suspended at the 0.5 depth. Water levels were

recorded at the Windmill Point, Fort Wayne, Wyandotte and Gibraltar gauges. Listed below are the controlling bench marks for the gauges referenced and the elevations of these bench marks.

<u>Water Level Gauges</u>	<u>Controlling Bench Mark</u>	<u>Bench Mark Elevations (feet) 1935 Datum</u>
Windmill Pt.	D-1	584.71
Fort Wayne	Box Cover	576.56
Wyandotte	H.L.M. 90	578.09
Gibraltar	No. 1	587.65

5.8.4 Discharge Computation.

The 1941 soundings showed that the section was untouched by the improvement work. The cross-sectional area remained the same as it had been in 1930, 1933 and 1937. Therefore, the panel areas previously determined were used to reduce the 1941 discharge measurements.

Observations indicated that the transverse distribution of the velocities near the mainland end of the section differed slightly from earlier determinations. This was obviously the effect of two scows, which were moored to the dock about 150 feet below the section. Velocity coefficients from 1937, modified to take care of the slight change due to the scows, were used in the reduction of the measurements.

The discharge measurements are documented in the U.S. Lake Survey Archive, file 3-2962, available at the U.S. National Oceanic and Atmospheric Administration/National Ocean Service, Silver Springs, Maryland. Table 5.28 (see Appendix C) summarizes these measurements.

5.9 Lower Detroit River, 1944.

5.9.1 Purpose.

Discharge measurements were made in the lower Detroit River to acquire additional hydraulic data for use in establishing equations of flow and in dealing with problems related to the effects of changes in the regimen of the river.

5.9.2 Description of Sections.

All the sections where discharge measurements were made for this survey were re-established from previous surveys.

The **Trenton Channel Section** was located at Wyandotte, Michigan, on the Trenton Channel, approximately 1,400 feet below the foot of Orange Street. The section was divided into seven panels. Ten discharge measurements were made, at this section, between August 5 and August 8, 1944.

The **Limekiln Crossing Section** was located approximately two miles north of Amherstburg, Ontario, 60 feet south of the Limekiln Crossing Rear Range Light. The section was divided into ten panels. Six discharge measurements were made between August 15 and August 18, 1944.

The **Amherstburg Channel Section** was located adjacent to the Mullen Coal Co. dock, north of Richmond Street in Amherstburg, Ontario. The section consisted of nine panels. Seven discharge measurements were made between August 22 and August 24, 1944.

The **Boblo Dike Section** (known as the Bois Blanc Dike Section in previous surveys) was located between the west side of Bois Blanc Island and the east dike of the Livingstone Channel, approximately 2,000 feet below Light 20. The section was divided into three panels. Six discharge measurements were made, at this section, between September 4 and September 5, 1944.

The **Dry Cut Section** was located in the upper Livingstone Channel, between Lights 24 and 22. The section was divided into six panels. Six discharge measurements were made, at this section, between September 2 and September 5, 1944.

The **Lower Cut Section** was located across the lower Livingstone Channel, between the piers which supported Lights 17 and 18. The section was divided into five panels. Six discharge measurements were made, at this section, during the period August 25 and August 26, 1944.

The **Sugar Island Dike Section** was located between Sugar Island and the east-west dike running from the Livingstone Channel dike. The section was divided into three panels. A total of five discharge measurements were made, at this section, on September 8 and September 9, 1944.

The **Sugar Island Section** extended between Sugar Island and Hickory Island. The section was divided into six panels. A total of five discharge measurements were made, at this section, on September 6 and September 7, 1944.

Discharge measurements were also made at the **Fort Wayne Section**, in 1944. These measurements are documented in Subsection 5.21.

The approximate locations of these discharge measurement sections are shown on Figure 5-5.



Figure 5-5

Lower Detroit River, 1944 Section Locations

5.9.3 Measurement Techniques.

All sections were sounded in 1944. No vertical velocity measurements were made during this survey. Discharge measurements were simultaneously made using three velocity meters suspended at the 0.5 depth (0.4 depth at the Dry Cut Section) in each panel.

Water levels were recorded at the following gauges: Windmill Point, Fort Wayne, Wyandotte, Ouellette, Wigle and Gibraltar. The Windmill Point gauge was located at the foot of Alter Road on the Grosse Pointe Recreation Park small boat wharf. For this series of measurements, a small recording gauge was installed in May, 1944, and removed in November, 1944. The Fort Wayne gauge was installed in August, 1944, on the downstream side of the U.S. Lake Survey District boat slip located at historic Fort Wayne, in Detroit, Michigan. A small self-registering gauge was installed, in May, 1944, at Krueger's Boathouse, 118 feet upstream of the former gauge site, at the foot of Orange Street. This gauge was removed in November, 1944. A small self-registering gauge was installed, on August 9, 1944, at the site of the old Ouellette gauge, opposite the Upper Entrance Light. This gauge was removed in November, 1944. The Wigle gauge was installed for the period April 29 to November 13, at the old Wigle Mill gauge site, at the north end of the concrete wharf of the Canadian Lighthouse depot. The Gibraltar gauge was a permanent gauge located at the foot of Grandview Avenue, Gibraltar, Michigan. The following is a list of the bench marks to which the gauges were referenced and the elevations of these bench marks.

<u>Water Level Gauge</u>	<u>Controlling Bench Mark</u>	<u>Bench Mark Elevations (feet) 1935 Datum</u>
Windmill Point	D-1	584.71
Fort Wayne	Corner	581.21
Wyandotte	Meyers	577.50
Ouellette	Lime	591.11
Wigle	Wigle	581.05
Gibraltar	D-54	584.65

5.9.4 Discharge Computation.

The panel areas used at all of the sections were determined from the soundings made in 1944. Transverse coefficients were determined from the 1944 measurements. The vertical velocity coefficients were determined from measurements made in the 1930s: Trenton Channel - 1937 for panels 1-3 and 1933 for panels 4-7; Limekiln Crossing - 1930 for panel 1, 1933 for panels 2-9 and 1937 for panel 10; Amherstburg and Sugar Island - 1933; Boblo Dike, Dry Cut, Lower Cut and Sugar Island Dike - 1937.

Discharges for each panel were first computed from each measurement of velocity by applying the appropriate vertical and transverse velocity coefficients and panel areas to the velocities measured at the 0.5 depth (0.4 depth at the Dry Cut Section). The discharges measured by a particular meter at each panel were summed across the section. The section discharges, as measured by each of the three meters, were averaged to be the discharge through the section for a particular measurement.

A report on this series of measurements can be found in file 3-3084 of the Great Lakes Hydraulics and Hydrology Branch Archives of the Detroit District, Corps of Engineers, Detroit, Michigan. Tables 5.29 to 5.36 (see Appendix C) summarize the 1944 discharge measurements made in the lower Detroit River.

5.10 Lower Detroit River, 1960.

In 1960, discharge measurements were made on the lower Detroit River; however, no information was recovered. File 3-3985 of the U.S. Lake Survey Archives, containing discharge measurements for this survey, is missing.

5.11 Lower Detroit River, 1963.

5.11.1 Purpose.

During the period April through June 1963, thirteen hydraulic sections were recovered or established, in order to determine the distribution of flow through the various channels of the lower Detroit River. The channels in which hydraulic sections were established are the Trenton, East Celeron, West Celeron, Upper Livingstone, Lower Livingstone, Limekiln, Hackett, Stony Island, Sugar Island, Sugar Island Dike, Boblo Dike, LaSalle and West Grassy Island.

5.11.2 Description of Sections.

Discharge measurements were made at the below described sections in the lower Detroit River and at the Fort Wayne Section (documented in Subsection 5.21).

The Trenton Channel Section, re-established from the 1944 survey, was located at Wyandotte, Michigan, on the Trenton Channel. The section was divided into five panels each 150 feet in width, except panel five, which was 230 feet in width. Thirty-seven discharge measurements were made, at this section, between June 25 and June 29 and between November 15 and November 22, 1963.

The East Celeron Section, established for this survey, was located between Grosse Ile Island and Celeron Island. The section was divided into four panels of 320 feet, 320 feet, 360 feet and 540 feet in width, respectively. Six discharge measurements were made between June 10 and June 15, 1963.

The **West Celeron Section**, established for this survey, was located between Celeron Island and Horse Island. The section was divided into seven panels. The five interior panels were 220 feet in width. Panels one and seven were 300 feet and 234 feet in width, respectively. Seven discharge measurements were made between June 12 and June 15, 1963.

The **Dry Cut Section**, re-established from the 1944 survey, was located in the upper Livingstone Channel, between Lights 24 and 22. The section was divided into four panels of 131 feet each. Twenty-three discharge measurements were made between May 3 and May 11, 1963.

The **Lower Cut Section**, re-established from the 1944 survey, was located across the lower Livingstone Channel, between the piers which supported Lights 17 and 18. The section was divided into three panels of 128 feet and one panel of 127 feet. Fourteen discharge measurements were made between April 26 and May 15, 1963.

The **Limekiln Section**, re-established from the 1944 survey, was located approximately two miles north of Amherstburg, Ontario, and 60 feet south of the Limekiln Crossing Rear Range Light. The section was divided into six panels. Panels one through three were each 150 feet in width and panels four, five and six were 230 feet, 220 feet and 202 feet in width, respectively. Ten discharge measurements were made at this section between May 14 and May 18, 1963.

The **Hackett Section**, established for this survey, was located across the lower Amherstburg Channel from Bois Blanc Island to the Canadian mainland. The section was divided into five panels. The interior panels were 200 feet in width. Panels one and five were 100 feet and 341 feet in width, respectively. Eighteen discharge measurements were made between April 17 and April 29, 1963.

The **Stony Island Section**, re-established from the 1937 survey, was located between Stony Island and Grosse Ile. The section was divided into four panels. The first three panels were 252 feet each in width and panel four was 504 feet wide. Nine discharge measurements were made, at this section, between May 29 and June 1, 1963.

The **Sugar Island Channel Section**, re-established from the 1944 survey, extended between Sugar Island and Hickory Island. The section was divided into four panels. The first panel was 181 feet in width and the remaining panels were each 150 feet wide. Sixteen discharge measurements were made between May 23 and May 27, 1963.

The **Sugar Island Dike Section**, re-established from the 1944 survey, was located between Sugar Island and the east-west dike running from the Livingstone Channel dike. The section was divided into three panels of 159 feet, 100 feet and 100 feet, respectively. Twelve discharge measurements were made between May 25 and May 28, 1963.

The **Boblo Dike Section**, re-established from the 1944 survey, was located between the west side of Bois Blanc Island and the east dike of the Livingstone Channel, approximately 2000 feet below Light 20. The section was divided into three panels of 100 feet, 100 feet and 193 feet, respectively. Twenty-three discharge measurements were made at this section between April 25 and May 7, 1963.

The **LaSalle Section**, established for this survey, was located between Fighting Island and LaSalle, Ontario. The section was divided into five panels. The three interior panels were each 200 feet in width, and panels one and five were 100 feet and 320 feet in width, respectively. Eighteen discharge measurements were made between June 19 and June 22, 1963.

The **West Grassy Section**, established for this survey, was located across the upper Trenton Channel, west of Grassy Island. The section was divided into four panels. The first three panels were 225 feet in width and panel four was 320 feet wide. Seven discharge measurements were made, at this section, between June 27 and June 29, 1963.

Discharge measurements were also made at the **Fort Wayne Section**, in 1963. These measurements are documented in Subsection 5.21.

The approximate locations of these discharge measurement sections are shown on Figure 5-6.

5.11.3 Measurement Techniques.

Each section was sounded by lead line with the positioning determined by transit intersection. Soundings were plotted to develop profiles for each section.

The direction of flow was determined by tracking weighted floats past the line of the following sections: East Celeron, West Celeron, Limekiln, Hackett, LaSalle and West Grassy Island. The direction of flow for the Stony Island, Sugar Island Channel and Sugar Island Dike Sections, determined in 1960, were considered to be unchanged and thus used for this survey. The direction of flow being parallel with the channel banks, as observed by floats, indicated a directional coefficient of unity throughout the following sections: Trenton Channel, Dry Cut, Lower Cut and Boblo Dike.

Discharge measurements were made using five Price current meters suspended at the 0.2 and 0.8 depths in each section, except at the East Celeron, West Celeron and Stony Island Sections, where certain panels were metered at the 0.6 depth, due to shallow water. The mean of the 0.2 and 0.8 velocities represented the mean velocity in the vertical, except in the shallow panels, where the 0.6 velocity was considered to represent the mean velocity in the vertical.

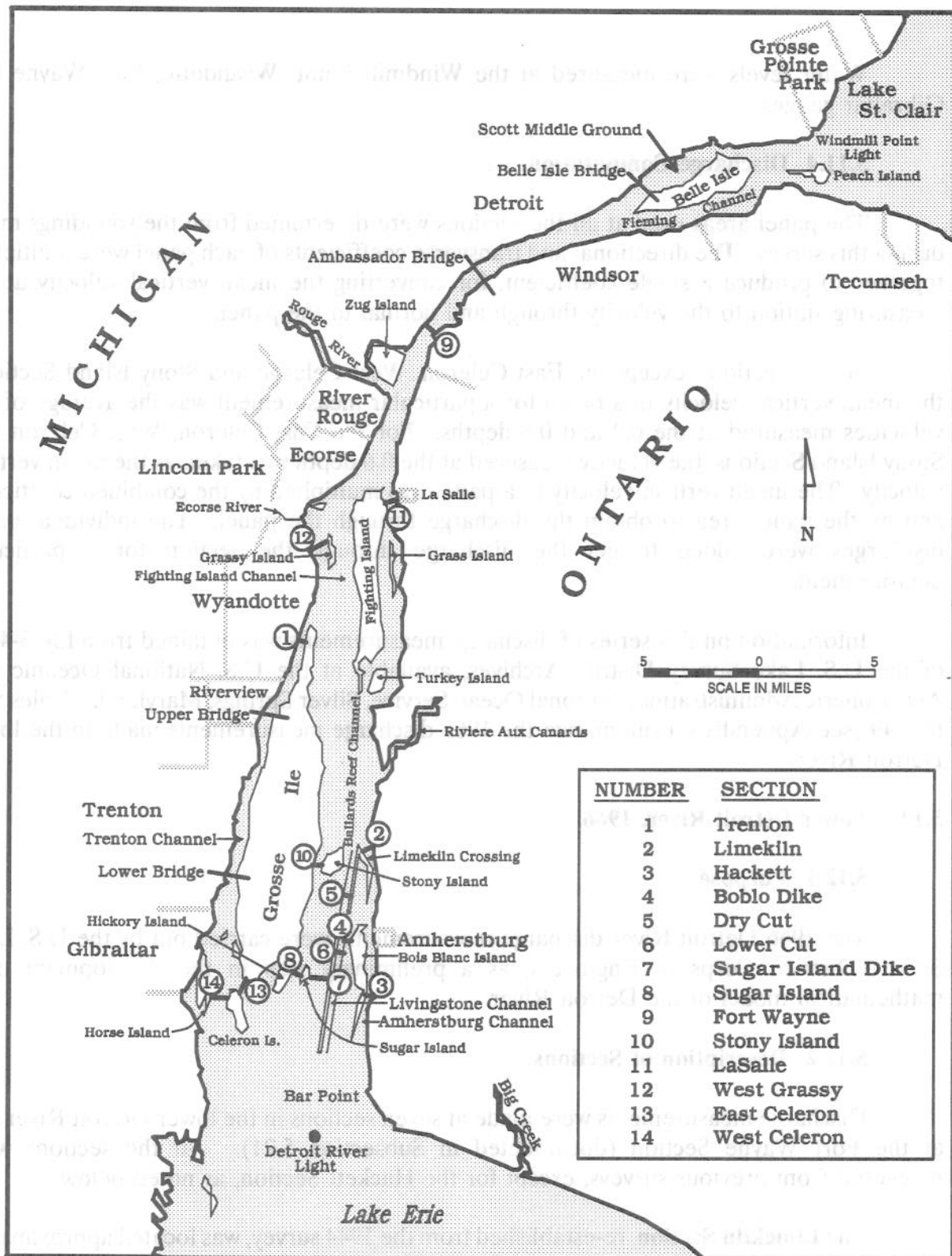


Figure 5-6

Lower Detroit River, 1963 Section Locations

Water levels were measured at the Windmill Point, Wyandotte, Fort Wayne and Gibraltar gauges.

5.11.4 Discharge Computation.

The panel areas used at all the sections were determined from the soundings made during this survey. The directional and transverse coefficients of each panel were multiplied together to produce a single coefficient, for converting the mean vertical velocity at the measuring station to the velocity through and normal to the panel.

For all sections, except the East Celeron, West Celeron and Stony Island Sections, the mean vertical velocity in a panel for a particular measurement was the average of the velocities measured at the 0.2 and 0.8 depths. For the East Celeron, West Celeron and Stony Island Sections, the velocity measured at the 0.6 depth was taken as the mean vertical velocity. The mean vertical velocity in a panel was multiplied by the combined coefficient and by the panel area to obtain the discharge through the panel. The individual panel discharges were added to get the discharge through the section for a particular measurement.

Information on this series of discharge measurements was obtained from file 3-4018 of the U.S. Lake Survey District Archives, available at the U.S. National Oceanic and Atmospheric Administration/National Ocean Service, Silver Springs, Maryland. Tables 5.37 to 5.49 (see Appendix C) summarize the 1963 discharge measurements made in the lower Detroit River.

5.12 Lower Detroit River, 1966.

5.12.1 Purpose.

The 1966 Detroit River discharge measurements were carried out by the U.S. Lake Survey District, Corps of Engineers, as a preliminary step in the development of a mathematical model of the Detroit River.

5.12.2 Description of Sections.

Discharge measurements were made at seven sections in the lower Detroit River and at the Fort Wayne Section (documented in Subsection 5.21). All the sections were recovered from previous surveys, except for the Hackett Section, as noted below.

The **Limekiln Section**, re-established from the 1944 survey, was located approximately two miles north of Amherstburg, Ontario, 60 feet south of the Limekiln Crossing Rear Range Light. The section was divided into six panels. A series of 30 discharge measurements were made during the period August 15 to August 31, 1966.

The **Stony Island Section**, re-established from the 1937 survey, was located between Stony Island and Grosse Ile. The section was divided into three panels. Forty-one discharge measurements were made, at this section, between August 19 and September 1, 1966.

The **Dry Cut Section**, re-established from the 1944 survey, was located in the upper Livingstone Channel, between Lights 24 and 22. The section was divided into 4 panels. A total of 32 measurements were made between August 15 and August 31, 1966.

The **Lower Cut Section**, re-established from the 1944 survey, was located across the lower Livingstone Channel, between the piers which support Lights 17 and 18. The section was divided into four panels. A series of 30 discharge measurements were made between July 8 and August 3, 1966.

The **Sugar Island Channel Section**, re-established from the 1944 survey, extended between Sugar Island and Hickory Island. The section was divided into 4 panels. Twenty-five discharge measurements were made, at this section, during the period July 14 to August 6, 1966.

The **Sugar Island Dike Section**, re-established from the 1944 survey, was located between Sugar Island and the east-west dike running from the Livingstone Channel dike. The section was divided into three panels. A total of 26 discharge measurement were made, at this section, during the period July 19 and August 8, 1966.

The **Hackett Section** was re-established in 1966 to a position approximately 300 feet upstream from where it was originally established. It extended across the lower Amherstburg Channel from Bois Blanc Island to the Canadian mainland. The section was divided into seven panels. A series of 27 discharge measurements were made, at this section, between July 9 and August 2, 1966.

The approximate locations of these discharge measurement sections are shown on Figure 5-6.

5.12.3 Measurement Techniques.

All of the sections were sounded in 1966, for determining panel areas, except for the Lower Cut Section.

To measure flows, as simultaneously as possible, two boats were utilized, each being located in a different channel at the same time. Whenever possible, three sections were metered in any one day. A daily rotation was maintained so that all sections were metered during approximately the same conditions of time, weather, stage, etc.

To measure discharge, velocity measurements were made at the 0.2, 0.4 and 0.8 depths of each panel, except at the Stony Island Section where measurements were only made at the 0.6 depth of the panels.

Water levels were measured at a gauge located at each section and at the Grosse Point Yacht Club, Windmill Point, Fort Wayne, Wyandotte and Gibraltar gauges. The section gauges were board gauges located at the water's edge on or near the section lines, except at the Stony Island Section. The gauge at that section was a Fischer-Porter automatic water level recorder, temporarily installed about 700 feet upstream of the section.

5.12.4 Discharge Computation.

The areas for all the sections, except the Lower Cut Section, were determined from the soundings made during this survey. The panel areas used for the Lower Cut Section were those computed in 1963.

The direction of flow coefficients used were those established in 1964; however, for the Hackett, Sugar Island Dike and Stony Island Sections, the 1964 coefficients were adjusted to compensate for changes in panel size and location of the index points. The direction of flow coefficients were multiplied by the transverse coefficients, determined from the 1966 velocity measurements, to obtain combined coefficients. The vertical velocity coefficients were assumed to be 1.0 for all sections.

For all sections, except the Stony Island Section, the mean vertical velocity in a panel for a particular measurement was the average of the velocities measured at the 0.2, 0.4 and 0.8 depths. For the Stony Island Section, the velocity measured at the 0.6 depth was taken as the mean vertical velocity. The mean vertical velocity in a panel was multiplied by the combined coefficient and by the panel area to obtain the discharge through the panel. The individual panel discharges were added to get the discharge through the section for a particular measurement.

Information on this series of discharge measurements was obtained from file GLHH 72-3 of the Great Lakes Hydraulics and Hydrology Branch Archives of the Detroit District, Corps of Engineers, Detroit, Michigan. Tables 5.50 to 5.56 (see Appendix C) summarize these discharge measurements.

5.13 Lower Detroit River, 1967.

In 1967, discharge measurements were made on the lower Detroit River; however, no information on these measurements was recovered. File 71-13 of the Great Lakes Hydraulics and Hydrology Branch Archives, Detroit District, Corps of Engineers, containing the discharge measurements for this survey, is missing.

5.14 Amherstburg-Gap and Bois Blanc Dike Sections, 1973.

5.14.1 Purpose.

These measurements were made to augment available data regarding flow in the Detroit River, especially for periods of high water levels. This survey was undertaken by the Great Lakes Hydraulics and Hydrology Branch of the Detroit District, Corps of Engineers, at the request of the Great Lakes Environmental Research Laboratory of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce .

5.14.2 Description of Sections.

The **Amherstburg-Gap Section** was established for this series of measurements. It was located approximately 2,500 feet northwest of Amherstburg, Ontario. This 979 foot wide section was divided into eight panels. A total of six discharge measurements were made, at this section, during the period September 7 to September 13, 1973.

The **Bois Blanc Dike Section**, established in 1933, was located approximately 3,000 feet west of Amherstburg, Ontario. The section extended a distance of 457 feet from the west shore of Bois Blanc Island to a point on the east side of the lower east Livingstone Channel Dike. The section was divided into 4 panels. A series of five discharge measurements were made, at this section, between September 8 and September 13, 1973.

The approximate locations of these discharge measurement sections are shown on Figure 5-7.

5.14.3 Measurement Techniques.

Soundings were made to establish the Amherstburg-Gap Section profile and to check the Bois Blanc Dike Section profile.

A drogue survey was conducted prior to the start of the discharge measurements for the Amherstburg-Gap Section, to determine the direction of flow in this area. The direction of flow in the Bois Blanc Dike Section was assumed to have remained the same as previously determined. The section line was constructed normal to the flow.

Discharge measurements were made using four Price current meters. One meter was held constant at the 0.4 depth of the panel, while the remaining three meters measured velocities at the 0.1 through 0.9 depths, by means of three separate settings of simultaneous readings.

During the period of discharge measurements, seven temporary water level recorders were installed at key locations. The section gauge for the Amherstburg-Gap Section was Gauge #3, while the water surface elevations for the Bois Blanc Dike Section were taken

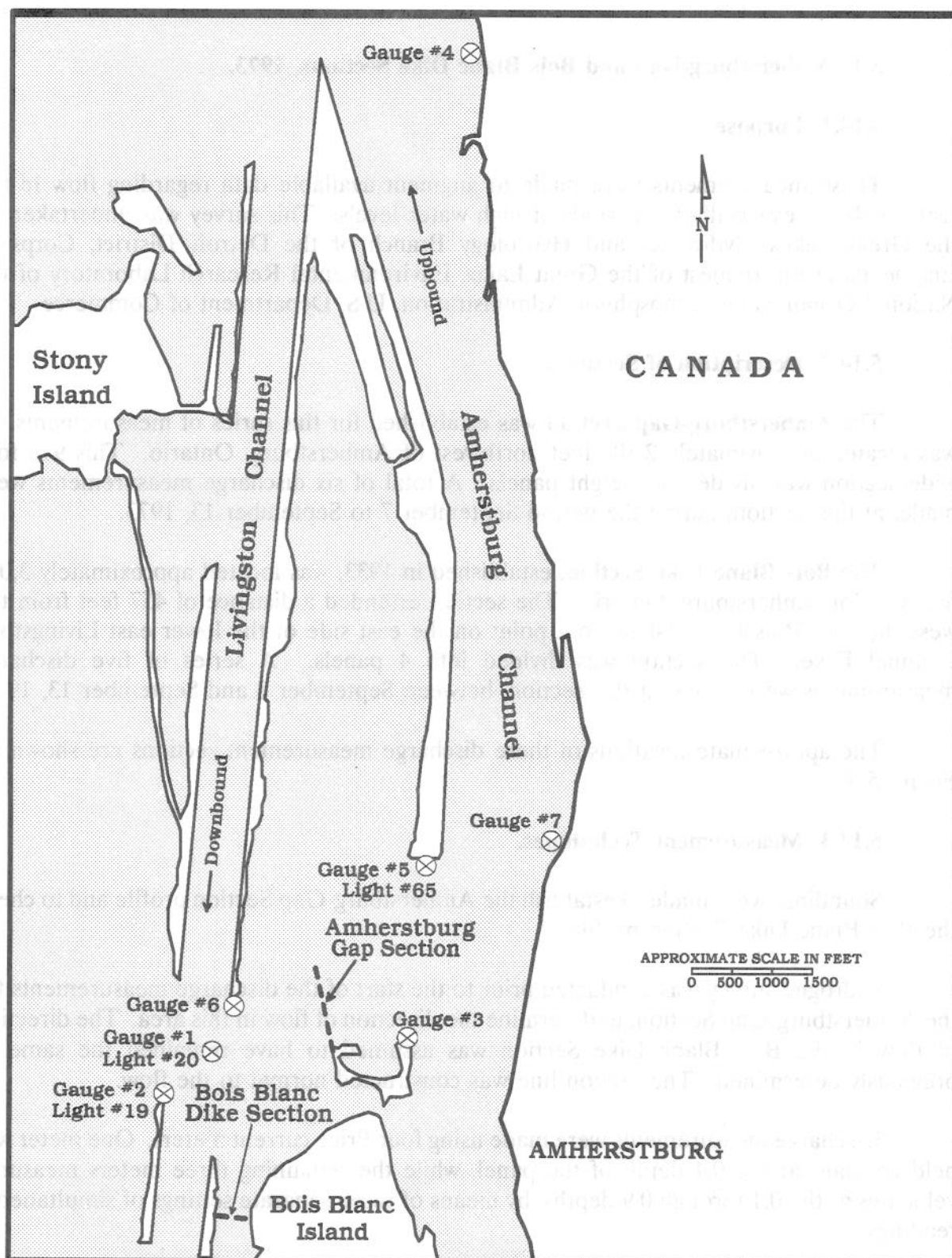


Figure 5-7
Detroit River, 1973 Amherstburg-Gap and Bois Blanc Dike Section Locations

from Gauge #2. Gauge #1 was placed on the Detroit River Light No. 20. Gauge #2 was on the Detroit River Light No. 19. Gauge #3 was on the northeast corner of the hook at the northerly end of Bois Blanc Island. Gauge #4 was at the forward entrance range of the Amherstburg Channel, on the Canadian shore. Gauge #5 was at Light No. 65 on the south jetty of the Amherstburg Channel Dike. Gauge #6 was at the south end of the east Livingstone Channel Dike. Gauge #7 was at Defours Dock, Amherstburg, Ontario.

5.14.4 Discharge Computation.

The data collected during the measurements were processed using the Detroit District, Corps of Engineers, discharge measurement program.

With the velocities at each of the nine tenth depths known, the average velocity in the vertical was computed. A modified von Karman equation was used to determine the configuration of the vertical velocity curve near the bottom and to compute the average velocity in the vertical.

After the average velocity in the vertical was computed for each panel, the area under the transverse curve for each panel was computed. This was accomplished by fitting a parabolic equation through at least three adjacent vertical velocity points. The computer then shifted over one vertical velocity point and fitted a curve through the next three points and so forth until the entire transverse curve was determined. In each case, the equation of the parabolic curve was integrated over the limits of the width of the panel to provide the area under the transverse curve for each panel. The area under the transverse velocity curve divided by the panel width was the average velocity for the panel, which was multiplied by the panel area to compute the panel discharge.

The panel areas were adjusted for variation in stage. The adjusted panel area was multiplied by the average panel velocity and by the directional coefficient for the panel to determine the flow normal to the panel. Individual panel discharges were summed to obtain the total section discharge.

The procedure described above was followed for each discharge measurement. In summary, an individual vertical velocity curve was developed for each panel for each measurement and the associated transverse velocity curve was developed for each discharge measurement. Using these techniques, errors induced by the application of average vertical velocity and transverse velocity coefficients were eliminated.

A report documenting this measurement series can be found in the Great Lakes Hydraulics and Hydrology Branch Archives, file GLHH 75-18, of the Detroit District, Corps of Engineers, Detroit, Michigan. Tables 5.57 and 5.58 (see Appendix C) summarize these discharge measurements.

5.15 Bar Point-Lee Section, 1975.

5.15.1 Purpose.

The 1975 Bar Point-Lee discharge measurements were carried out at the request of the Buffalo District, Corps of Engineers, as part of their waste water management studies. These series of measurements were also provided for, and copies supplied to, the Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, for a check on their Detroit River discharge equation and associated hydraulic studies.

5.15.2 Description of Section.

The Bar Point-Lee Section was located on the extreme lower end of the Detroit River, approximately 2.5 miles south of Gibraltar, Michigan, and approximately 2,000 feet east of the east-west portion of Lee Road at Maple Beach, then running east on a magnetic azimuth of 90° to Bar Point, at Summit Beach, Ontario, Canada. The section was divided into 20 panels. A total of 6 measurements were made during the period May 5 through October 3, 1975.

The approximate location of this discharge measurement section is shown on Figure 5-8.

5.15.3 Measurement Techniques.

Although the section was sounded, a direction of flow study was not undertaken; it was assumed that the flow was normal to the section line.

Discharge measurements were made using four Price current meters. One meter was held constant at the 0.4 depth of the panel, while the remaining three meters measured velocities at the 0.1 through 0.9 depths, by means of three separate settings of simultaneous readings. Water levels were recorded at the St. Clair Shores, Fort Wayne, Wyandotte, Gibraltar and Windmill Point gauges.

5.15.4 Discharge Computation.

The data collected during the measurements were processed using the Detroit District, Corps of Engineers, discharge measurement program.

The discharge computation was as described in Subsection 5.14.4.

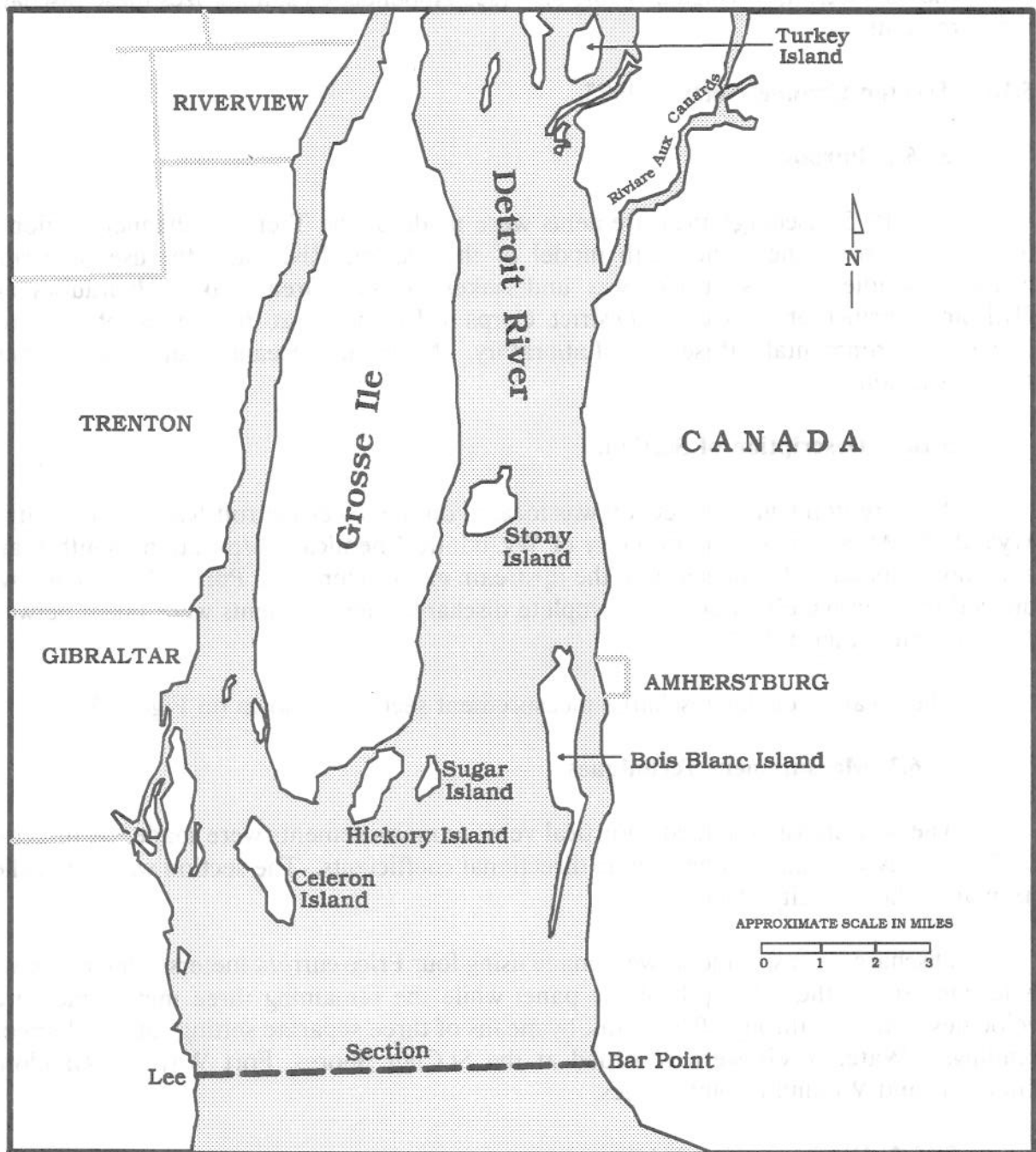


Figure 5-8

Lower Detroit River, 1975 Bar Point-Lee Section Location

A report documenting this measurement series can be found in the Great Lakes Hydraulics and Hydrology Branch Archives, file GLHH 75-15, of the Detroit District, Corps of Engineers, Detroit, Michigan. Table 5.59 (see Appendix C) summarizes these discharge measurements.

5.16 Trenton Channel Section, 1975.

5.16.1 Purpose.

The 1975 discharge measurements were made at the Trenton Channel Section to obtain data to augment the math model of the Detroit River and for use in various hydraulic studies. This project was undertaken by the Great Lakes Hydraulics and Hydrology Branch of the Detroit District, Corps of Engineers, at the request of the Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration.

5.16.2 Description of Section.

The Trenton Channel Section was located on the lower Detroit River, in the City of Wyandotte, Michigan, on the property of Wyandotte Chemical Corporation (South Plant) and approximately 0.6 mile south of the upstream end of Hennepin Point. The section was divided into ten panels. Fourteen complete discharge measurements were taken between August 1 and August 7, 1975.

The location of this discharge measurement section is shown on Figure 5-9.

5.16.3 Measurement Techniques.

The section was sounded. Vertical velocity measurements were made. A direction of flow survey was made to determine directional coefficients. The section was established normal to the majority of flow.

Discharge measurements were made using four Price current meters. One meter was held constant at the 0.4 depth of the panel while the remaining three meters measured velocities at the 0.1 through 0.9 depths, by means of three separate settings of simultaneous readings. Water levels were recorded at the St. Clair Shores, Fort Wayne, Wyandotte, Gibraltar and Windmill Point gauges.

5.16.4 Discharge Computation.

The data collected during the measurements were processed using the Detroit District, Corps of Engineers, discharge measurement program.

The discharge computation was as described in Subsection 5.14.4.

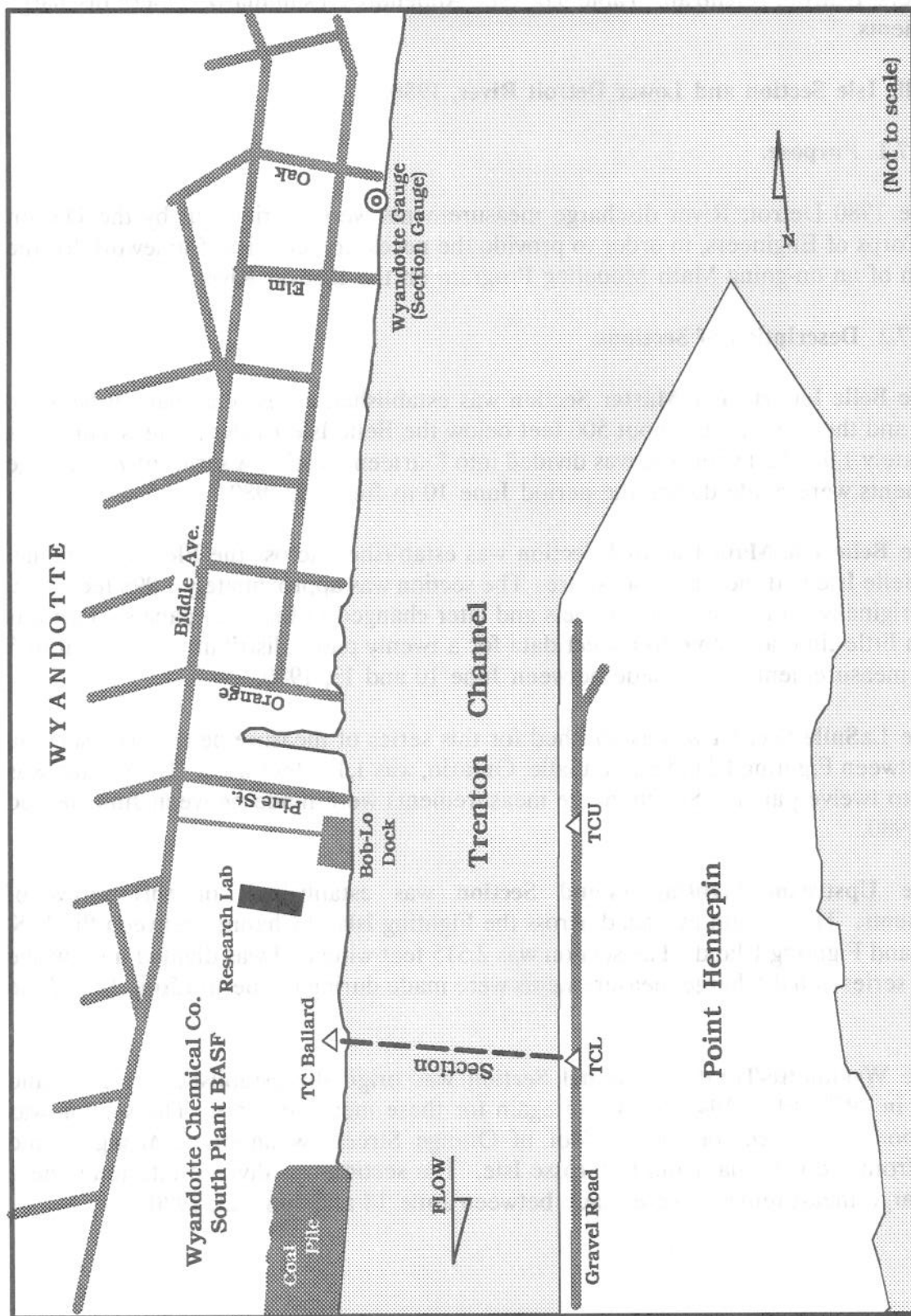


Figure 5-9

Lower Detroit River, 1975 Trenton Channel Section Location

A report documenting this measurement series can be found in the Great Lakes Hydraulics and Hydrology Branch Archives, file GLHH 75-73, of the Detroit District, Corps of Engineers, Detroit, Michigan. Table 5.60 (see Appendix C) summarizes these discharge measurements.

5.17 Belle Isle Section and Lower Detroit River, 1980.

5.17.1 Purpose.

The 1980 Detroit River discharge measurements were carried out by the Detroit District, Corps of Engineers, in order to provide the necessary technical framework for the calibration of an on-going Math Modeling Program on the Detroit River.

5.17.2 Description of Sections.

The **Belle Isle Harbor Master Section** was established across the channel between Belle Isle and the U.S. shore (about 500 feet below the Belle Isle Bridge). The section was approximately 1,924 feet wide and was divided into fourteen panels. A series of 7 discharge measurements were made during the period June 10 to June 13, 1980.

The **Belle Isle Main Channel Section** was established across the Fleming Channel between Belle Isle and the Canadian shore. The section was approximately 1,996 feet wide, and was originally set up for twenty panels and later changed to fourteen panels. This was due to too little time available to collect data for a twenty panel distribution. A total of 5 discharge measurements were made between June 10 and 13, 1980.

The **LaSalle Section** was established for this series of measurements. The section, located between Fighting Island and LaSalle, Ontario, was 1,175 feet wide. The section was divided into twelve panels. Six discharge measurements were made between June 18 and June 23, 1980.

The **Upstream Fighting Island Section** was established for this series of measurements. The section extended across the Fighting Island Channel between the U.S. mainland and Fighting Island. The section was 2,515 feet wide and was divided into twelve panels. A series of 6 discharge measurements were made during the period June 18 to June 23, 1980.

The **Wyandotte-Trenton Channel Section** was originally established in 1930 and recovered in 1933, 1937, 1941, 1944 and again for these measurements. The section was located about 1,500 feet below the foot of Orange Street, Wyandotte, Michigan, and extended from the U.S. mainland to Grosse Isle. The section was divided into ten panels. Ten discharge measurements were made between June 18 and June 23, 1980.

The **Limekiln Section**, re-established from the 1944 survey, was located approximately two miles north of Amherstburg, Ontario, 60 feet south of the Limekiln Crossing Rear Range Light. The section was divided into five panels. A series of 7 discharge measurements were made during the period June 26 to July 1, 1980.

The **Livingstone-Stony Section** was established for this series of measurements. The section was located across the Livingstone Channel, between and near the top of the dikes. The section was approximately 509 feet wide and was divided into five panels. A total of 7 discharge measurements were made between June 26 and July 1, 1980.

The **Stony Island Section**, re-established from the 1937 survey, was located between Stony Island and Grosse Ile. The section was divided into six panels. A total of 6 discharge measurements were made, at this section, between June 26 and July 1, 1980.

The **Bois Blanc Dike Section** was established in 1933. It was located approximately 3,000 feet west of Amherstburg, Ontario. The section extended a distance of 457 feet from the west shore of Bois Blanc Island to a point on the east shore of the lower east Livingstone Channel Dike. The section was divided into four panels. A series of 21 discharge measurements were made between June 25 and July 1, 1980.

The **Downstream Livingstone Section** was established for this series of measurements. The section was 608 feet wide and extended between the dikes of the Livingstone Channel, adjacent to Bois Blanc Island. The section was divided into four panels. A series of 13 discharge measurements were made between June 25 and July 1, 1980.

The **Sugar Island Channel Section** extended between Sugar Island and Hickory Island. The section was divided into four panels. A total of 9 discharge measurements were made, at this section, between June 25 and July 1, 1980.

The **Sugar Island Dike Section**, re-established from the 1944 survey, was located between Sugar Island and the east-west dike running from the Livingstone Channel dike. The section was divided into four panels. A total of 10 discharge measurements were made between June 26 and July 1, 1980.

The approximate locations of these discharge measurement sections are shown on Figure 5-10.

5.17.3 Measurement Techniques.

Soundings and vertical velocity measurements were made at all the sections. A direction of flow survey was made to determine directional coefficients. The sections were established normal to the majority of flow.



Figure 5-10

Belle Isle and Lower Detroit River, 1980 Section Locations

To measure flow as simultaneously as possible, three survey vessels along with two support skiffs were utilized, each being located in a different channel at the same time. A daily rotation was maintained so that all sections were metered during approximately the same conditions of time, weather, stage, etc.

Velocity measurements, for the computation of discharge, were made using four Price current meters. One meter was held constant at the 0.4 depth of the panel, while the remaining three meters measured velocities at the 0.1 through 0.9 depths, by means of three separate settings of simultaneous readings.

Water levels were recorded at eleven gauges: Windmill Point, Belle Isle C.G., Mt. Elliot C.G., Fort Wayne, Wyandotte, Trenton, Gibraltar, Tecumseh, LaSalle, Amherstburg and Bar Point. Water level gauges at Belle Isle, Mt. Elliot and Trenton were newly installed by the Detroit District, Corps of Engineers, in the early spring of 1980. The Windmill Point gauge was located near the head of the Detroit River at the foot of Alter Road in Detroit, Michigan. The Belle Isle C.G. gauge was installed at the U.S. Coast Guard Slip, Detroit, Michigan. The Trenton gauge was located at Trenton, Michigan. The Fort Wayne gauge was located on the Corps of Engineers slip at the foot of Livernois Ave., at historic Fort Wayne in Detroit, Michigan. The Wyandotte gauge was located at the foot of Orange Street, Wyandotte, Michigan. The Gibraltar gauge was installed on the north face of Hall's Dock at the foot of Grandview Ave., Gibraltar, Michigan. The Wigle gauge was installed at the north end of the concrete wharf of the Canadian Lighthouse depot at Amherstburg, Ontario. The Tecumseh gauge was installed on the Canadian mainland near Peach Island in Windsor, Ontario. The LaSalle gauge was located on the Canadian mainland near Fighting Island. The Bar Point gauge was installed on the Canadian mainland at Bar Point, Ontario.

5.17.4 Discharge Computation.

The data collected during the measurements were processed using the Detroit District, Corps of Engineers, discharge measurement program.

The discharge computation was as described in Subsection 5.14.4.

Documentation of this measurement series can be found in the Great Lakes Hydraulics and Hydrology Branch Archives, file GLHH 86-09, of the Detroit District, Corps of Engineers, Detroit, Michigan. Tables 5.61 through 5.72 (see Appendix C) summarize these discharge measurements.

5.18 North Peach Island Section, 1981.

5.18.1 Purpose.

The 1981 North Peach Island (presently referred to as Peche Island) discharge measurements were carried out by the Detroit District, Corps of Engineers, in order to provide the necessary technical framework for the calibration of an on-going Math Modeling Program on the Detroit River.

5.18.2 Description of Section.

The North Peach Island Section was established across the channel between Peach Island and the Canadian shore. The section was approximately 1,150 feet wide and was divided into five panels. A series of 3 discharge measurements were made on May 29, 1981.

The location of this discharge measurement section is shown on Figure 5-11.

5.18.3 Measurement Techniques.

The section was sounded in 1981. Vertical velocity measurements were also made during this survey. The section was established normal to the majority of flow. Discharge measurements were made using three velocity meters. Velocity measurements were taken at each of the tenth depths in each panel. Water levels were recorded at the Fort Wayne, Wyandotte and Gibraltar gauges.

5.18.4 Discharge Computation.

The data collected during the measurements were processed using the Detroit District, Corps of Engineers, discharge measurement program.

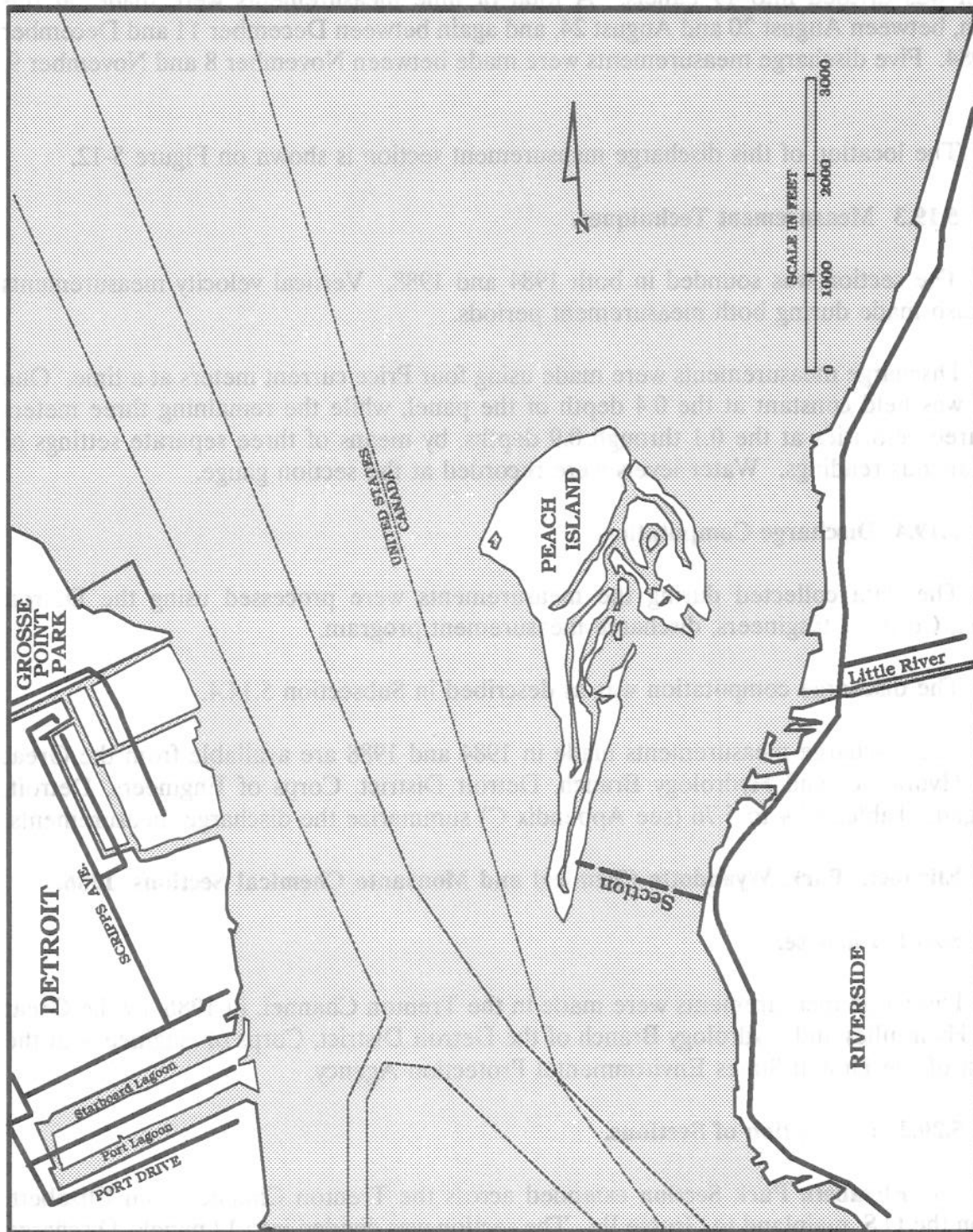
The discharge computation was as described in Subsection 5.14.4.

Documentation of this measurement series can be found in the Great Lakes Hydraulics and Hydrology Branch Archives, file GLHH 86-10, of the Detroit District, Corps of Engineers, Detroit, Michigan. Table 5.73 (see Appendix C) summarizes these discharge measurements.

5.19 Revere Section, 1984 and 1988.

5.19.1 Purpose.

The 1984 and 1988 discharge measurements were made at the Revere Section to calibrate electromagnetic velocity meters.



Detroit River, 1981 North Peach Island Section Location

Figure 5-11

5.19.2 Description of Section.

The Revere Section was located 100 feet upstream of the Fort Wayne gauge. The section was divided into 19 panels. A total of nine measurements were made, at this section, between August 20 and August 24, and again between December 11 and December 14, 1984. Five discharge measurements were made between November 8 and November 9, 1988.

The location of this discharge measurement section is shown on Figure 5-12.

5.19.3 Measurement Techniques.

The section was sounded in both 1984 and 1988. Vertical velocity measurements were also made during both measurement periods.

Discharge measurements were made using four Price current meters at a time. One meter was held constant at the 0.4 depth of the panel, while the remaining three meters measured velocities at the 0.1 through 0.9 depths, by means of three separate settings of simultaneous readings. Water levels were recorded at the section gauge.

5.19.4 Discharge Computation.

The data collected during the measurements were processed using the Detroit District, Corps of Engineers, discharge measurement program.

The discharge computation was as described in Subsection 5.14.4.

The discharge measurements made in 1984 and 1988 are available from the Great Lakes Hydraulics and Hydrology Branch, Detroit District, Corps of Engineers, Detroit, Michigan. Tables 5.74 to 5.76 (see Appendix C) summarize the discharge measurements.

5.20 Elizabeth Park, Wyandotte Chemical and Monsanto Chemical Sections, 1986.

5.20.1 Purpose.

Discharge measurements were made in the Trenton Channel, in 1986, by the Great Lakes Hydraulics and Hydrology Branch of the Detroit District, Corps of Engineers, at the request of the United States Environmental Protection Agency.

5.20.2 Description of Sections.

The Elizabeth Park Section extended across the Trenton Channel from Elizabeth Park on the U.S. mainland to Grosse Ile. The section was divided into 12 panels. Discharge

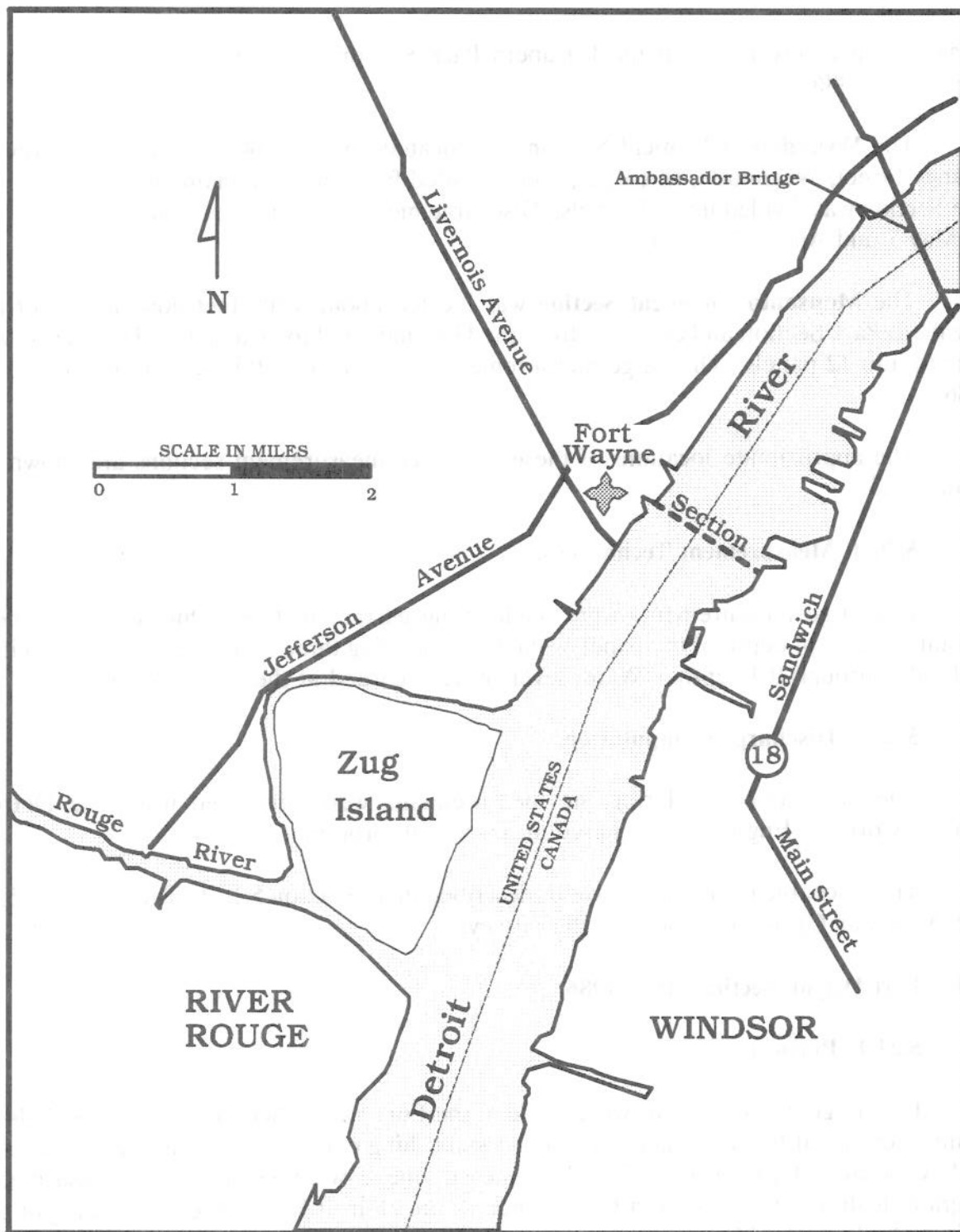


Figure 5-12

Detroit River, 1984 & 1988 Revere Section Location

measurements were made, at the Elizabeth Park Section, on May 6 and 7 and again on August 27, 1986.

The **Wyandotte Chemical Section** was located about 1,500 feet below the foot of Orange Street, Wyandotte, Michigan, and extended from the U.S. mainland to Grosse Ile. The Section was divided into 12 panels. Discharge measurements were made at this section on May 7 and August 27, 1986.

The **Monsanto Chemical Section** was located about 6,500 feet downstream of the Elizabeth Park Section and extended from the U.S. mainland to Grosse Ile. The section was divided into 12 panels. Discharge measurements were made at this section on August 26, 1986.

The approximate locations of these discharge measurement sections are shown on Figure 5-13.

5.20.3 Measurement Techniques.

Discharge measurements were made using current meters. One meter was held constant at the 0.4 depth of the panel, while the remaining three meters measured velocities at the 0.1 through 0.9 depths. Water levels were recorded at the section gauges.

5.20.4 Discharge Computation.

The data collected during the measurements were processed using the Detroit District, Corps of Engineers, discharge measurement program.

The discharge computation was as described in Subsection 5.14.4. Tables 5.77 to 5.79 (see Appendix C) list the results of this survey.

5.21 Fort Wayne Section, 1943-1986.

5.21.1 Purpose.

Discharge measurements were made at the Fort Wayne Section in 1943 and 1944 to acquire additional hydraulic data for use in establishing equations to compute the flows in the St. Clair and Detroit Rivers. The 1944 measurements were also part of a measurement program dealing with changes in the regimen of the Detroit River, due to dredging of the navigation channel. Measurements were again made at this section in 1948, 1949, 1950, 1952, 1959, 1960-1964, 1966 and 1968 for the purpose of providing additional data for hydraulic studies of the Detroit River. The 1952 measurements were made in connection with a study to determine if the flow past a calibrated hydraulic section could be determined equally well from velocities observed at one station instead of several. The 1966 measurements were taken also to augment the data previously obtained for determining the

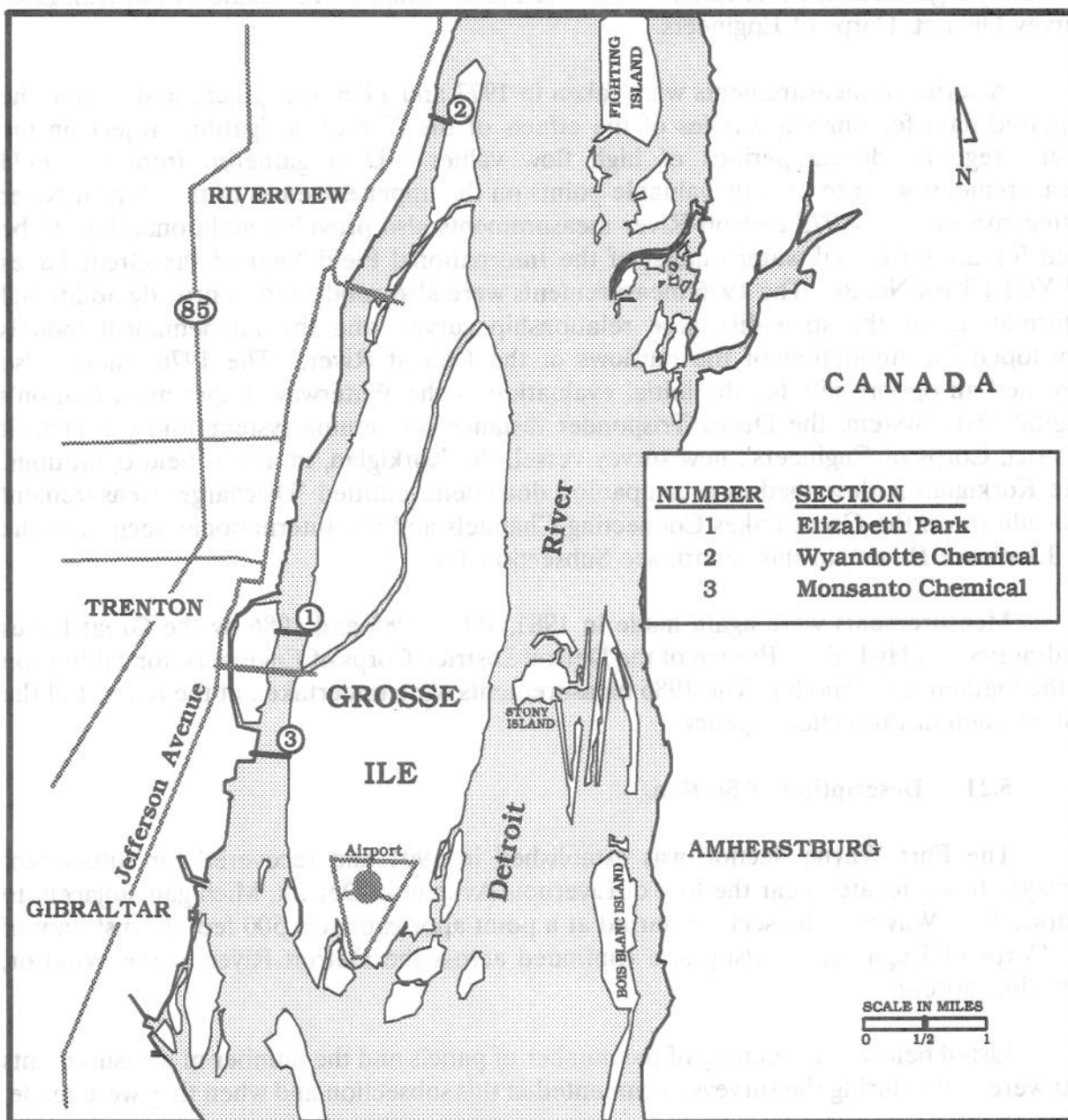


Figure 5-13

Detroit River, 1986 Section Locations

regimen of the post 27-foot navigation project; that is, to obtain data for a period of extremely high Detroit River flows. All above measurements were made by the U.S. Lake Survey District, Corps of Engineers.

A series of measurements were taken in 1973 and 1976 to augment and update the acquired data for ongoing studies of the effects of the 27-foot navigation project on the river's regimen during periods of high flow values. Data gathered from the 1973 measurements were to provide valuable points on the upper extremes of the Detroit River rating curves. The 1973 Detroit River measurements also provided additional data to be used for the terrestrial water budget of the International Field Year of the Great Lakes (IFYGL) Task No. 24. The 1976 measurements were also conducted to provide additional information for the stage-discharge relationship curves, and the mathematical models developed for simulation of the outflows of the Detroit River. The 1976 studies also provided an opportunity for the initial evaluation of the Waterways Experiment Station's Digital Data System, the Decca Trisponder distance positioning system, and the Detroit District, Corps of Engineers', new survey vessel, the Korkigian, in actual field operations. The Korkigian is described in a companion document, entitled "Discharge Measurement Procedures on the Great Lakes Connecting Channels and the International Section of the St. Lawrence River", to this report, see Subsection 1.3.

Measurements were again made in 1981, 1984, 1985 and 1986 by the Great Lakes Hydraulics and Hydrology Branch of the Detroit District, Corps of Engineers, for calibration of the mathematical model. The 1986 measurements were undertaken at the request of the Environmental Protection Agency.

5.21.2 Description of Section.

The Fort Wayne Section was established in 1901 and recovered for subsequent surveys. It was located near the foot of Livernois Avenue in Detroit, Michigan, adjacent to historic Fort Wayne. The section started at a point approximately 500 feet downstream of the Corps of Engineers boatslip and continued across the Detroit River to the Windsor, Ontario, shoreline.

Listed below is a summary of the number of panels and the number of measurements that were made during the surveys documented in this subsection and when they were made.

<u>Date of Survey</u>	<u>Number of Panels</u>	<u>Number of Measurements</u>
May 7 - 20, 1943	12	12
July 27 - September 19, 1944	16	22
June 11 - 22, 1948	19	12
October 17 - 26, 1949	12	15
June 14 - 27, 1950	11	20

Continued from Previous Page

October 4 - 17, 1950	11	20
August 25 - September 4, 1952	11	12
November 25 - December 11, 1959	10	20
July 12 - 27, 1960	10	24
November 4 - 28, 1960	10	17
May 16 - June 9, 1961	10	35
July 27 - August 17, 1962	10	31
October 28 - December 5, 1963	10	22
June 10 - July 10, 1964	10	38
May 14 - 31, 1966	10	24
September 14 - October 12, 1966	10	30
May 13 - June 8, 1968	21	30
May 15 - June 8, 1973	21	20
September 29 - October 14, 1976	21	7
May 15 - 29, 1981	21	10
August 27 - September 7, 1984	20	9
August 8 - 16, 1985	20	7
April 23 - 25, 1986	18	3

The location of this discharge measurement section is shown on Figure 5-1.

5.21.3 Measurement Techniques.

During the individual surveys, the section was sounded prior to each series of measurements.

For the series of measurements made in 1943, discharge measurements were made at each panel point by suspending two current meters at the mid-depth (0.5 depth) of the panel, simultaneously. In 1949, four velocity meters in combinations of three were used simultaneously to measure the discharge of each panel. In 1950, the discharge measurements were made using five current meters suspended at the 0.5 depth of a panel and in 1952 the discharge measurements were made using three meters. The observations made in 1959 measured velocities at the 0.2 and 0.8 depths of the panels, using two Price meters, three Ott meters and two Neyrpic meters. The 1960 velocity measurements, for computation of discharge, were made at the 0.2 and 0.8 depths, using two Neyrpic meters. In 1961, observations were made simultaneously at the 0.2 and 0.8 depths in each of ten panels of the section, using three Price meters, one Ott meter and one Neyrpic meter. To measure discharges in 1962, 1963 and 1964, velocity measurements were made at the 0.2, 0.4 and 0.8 depths of each panel, using five Price meters in combination of three, recording simultaneously. In 1966, six Price meters were used on a rotational basis, utilizing three at a time for metering at the 0.2, 0.4, and 0.8 depths. From 1973 through 1986, velocity measurements were taken at each of the tenth depths in each panel.

During the 1943 survey, at the Fort Wayne Section, water level elevations were monitored at the following gauges: Grosse Pointe Yacht Club, Windmill Point, Fort Wayne, Gibraltar, Detroit River Light and Cleveland. The Grosse Pointe Yacht Club gauge was located at the foot of Vernier Road, on Lake St. Clair, at the Grosse Pointe Yacht Club, approximately five miles above the mouth of the Detroit River. The Windmill Point gauge was located at the terminus of Lake St. Clair and the beginning of the Detroit River near the foot of Alter Road, on the Public Health Service property in Detroit, Michigan. The Fort Wayne gauge was located on the Corps of Engineers boatslip at the foot of Livernois Avenue, Detroit, Michigan. The Gibraltar gauge was located at the foot of Grandview Avenue, Gibraltar, Michigan. The Detroit River Light gauge was located at the upstream face of the Detroit River Light lighthouse in the Detroit River. The Cleveland gauge was located at the foot of Ninth Street, Cleveland, Ohio.

In 1944, water levels were recorded at two additional gauges: Wyandotte and Wigle. The Wyandotte gauge was located at the foot of Orange Street, Wyandotte, Michigan. The Wigle gauge was located in Amherstburg, Ontario, at the north end of the concrete wharf of the Canadian Lighthouse depot.

In 1948, water levels were recorded at the following gauges: Windmill Point, Fort Wayne, Wyandotte, Upper Entrance Light, Gibraltar and Detroit River Light; while in 1950 and 1952, water levels were recorded at the following gauges: Grosse Pointe Yacht Club, Windmill Point, Fort Wayne, Wyandotte, Upper Entrance Light, Gibraltar, Detroit River Light and Cleveland.

In 1959, water levels were recorded at four gauges: Grosse Pointe Yacht Club, Windmill Point, Fort Wayne and Ouellette. During the period from July 20 to October 20, 1960, the Fort Wayne gauge was moved from its original position at the outer downstream end of the dock to the inside downstream end of the slip.

In 1961, water levels were recorded at the Grosse Pointe Yacht Club, Windmill Point, Fort Wayne, Wyandotte, Amherstburg, Gibraltar and Cleveland gauges. The Amherstburg gauge was located in the Wyandotte Indian Cemetery, approximately three miles north of the town of Amherstburg, Ontario.

In 1973, water levels were recorded at the St. Clair Shores, Windmill Point, Fort Wayne, Wyandotte and Gibraltar gauges. The St. Clair Shores gauge was located at the north end of the U.S. Coast Guard property, on Lake St. Clair, at the foot of Revere Avenue in St. Clair Shores, Michigan.

Listed below are the bench marks to which the water level gauges were referenced and the elevations of these bench marks.

<u>Water Level Gauge</u>	<u>Controlling Bench Mark</u>	<u>Bench Mark Elevation (feet) 1935 Datum</u>
G.P.Y.C.	Yacht Club	579.84
Windmill Point	D - 1	584.71
Fort Wayne	Fort	588.46
Gibraltar	D - 54	584.65
Det.R.Light	Det.R.Light	584.33
Cleveland	Door step	582.44
Wyandotte	Meyers	577.50
Wigle	Wigle	581.05
Upper Ent. Light	Canada Light	578.45
Amherstburg	Rhequme	-----
St. Clair Shores	Food	-----

5.21.4 Discharge Computation.

For all measurements documented in this section, the discharge through the Fort Wayne Section was the total of the discharges through the panels. For the measurements made between 1943 and 1986, the discharge through the panel, during the particular measurement, was determined by multiplying the area of the panel by the measured velocity and by a combined coefficient. The combined coefficient for these measurements was obtained by multiplying the directional, vertical and transverse coefficients.

Panel areas were determined based on the soundings made at the time; however, for the 1949 computations, panel areas used in the reduction of measurements were the areas determined in 1948. Furthermore, for the 1952 calculations, the cross sectional area used in the reduction of the measurements was the mean value of all the soundings made at the Fort Wayne Section, from 1928 to date, for panels 3 to 9, inclusive. The area used for panels 1, 2, 10 and 11 was the mean value of two determinations made in 1950. The mean of the panel areas of the 1959 and 1960 soundings was used for the 1960 calculations.

In general, from the vertical velocity measurements the vertical velocity coefficients were determined for each panel. From the velocity measurements at the 0.5 depth of each panel in a section, transverse velocity curves were drawn and coefficients determined. The directional coefficients were also established.

For the period 1943 - 1949, the transverse velocity coefficients were multiplied by the vertical velocity coefficients to obtain the combined coefficients. In 1950, the directional coefficients were determined from previous measurements and had a value of 1.0 for each station. In 1959, 1960, 1961, 1963 and 1966, the transverse velocity coefficients were multiplied by the directional coefficients to obtain the combined coefficients. In 1964, the vertical velocity coefficients, transverse velocity coefficients and directional coefficients were

multiplied to get combined coefficients. In 1973 and 1976, only directional coefficients were used.

Discharges were first computed for each panel for each measurement of velocity, by applying the appropriate vertical, transverse or directional coefficients and panel areas to the velocities measured at the 0.5 depth of a panel. In 1959 through 1966, the mean vertical velocity in a panel for a particular measurement was the average of the velocities measured at the 0.2 and 0.8 depths.

In 1973, the discharges for the 1959 - 1966 measurements were recomputed using a modified version of the computer program written by the Corps of Engineers. The program inputs were the panel areas, the vertical and directional coefficients for each panel, the velocity observations for each panel and each measurement and the water level at the section gauge. The velocity in the vertical of a panel was the average of all velocity observations for the measurement multiplied by the vertical coefficient. The transverse velocity was computed in the same manner as that used in 1968. The 1981-1986 measurements were also computed using the Corps of Engineers' computer program.

Reports and data from these surveys are kept in the Great Lakes Hydraulics and Hydrology Branch Archives of the Detroit District, Corps of Engineers, Detroit, Michigan. The year of the surveys and the number of the archive files are listed below.

<u>Year</u>	<u>File Number</u>
1943	3-3004
1944	3-3039
1948	3-3168
1949	3-3145
1950	3-3294 and 3-3296
1952	3-3350
1959	3-3977
1960	3-3978
1961	3-3979
1962	3-3980
1963	3-4020
1964	3-4136
1966	3-4357
1968	73-16
1973	75-2
1976	77-5
1981	86-10
1984	91-25
1985	91-25
1986	91-25

Tables 5.80 through 5.100 (see Appendix C) summarize the discharge measurements made, at the Fort Wayne Section, during the period 1943 to 1986.

5.22 Summary of Discharge Measurements.

For easy reference, a matrix of the identifiable historical Detroit River discharge measurements is provided in Table 5.1. The table contains only basic information in an abbreviated format; therefore, for more information on a particular series of measurements refer to the noted subsection in the table.

TABLE 5.1 Summary of Detroit River Discharge Measurements

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
Fort Wayne (See Subsection 5.1)	July 19 - Dec. 10, 1901 & June 25 - Nov. 20, 1902	To develop stage-discharge relationships	On the Detroit River, adjacent to historical Fort Wayne in Detroit, MI	Conventional	Tables 5.1 & 5.2
Trenton Channel (See Subsection 5.2)	Aug. 29 - Dec. 5, 1912; Aug. 31 & Oct. 27, 1922; Oct. 8 & 9, 1923; Aug. 7 - Oct. 18, 1924 & Jul. 27 - Aug. 4, 1925	Not Known	Not Known	Not Known	Table 5.3
Fort Wayne (See Subsection 5.3)	Sept. 14 - 20, 1928, July 19 - 30, 1930, Sept. 12 - 27, 1933 & June 29 - July 19, 1937	To gather additional base data for a stage-discharge relationship and to determine the distribution of flow through channels in the lower river	On the Detroit River, adjacent to historical Fort Wayne in Detroit, MI	Conventional	Tables 5.4 - 5.7
Lower Detroit River: Trenton Channel, (See Subsection 5.4)	July 12 - 15, 1930	To measure the distribution of flow in the lower Detroit River (prior to the deepening of the channels for navigation)	1500 ft below the foot of Orange Street in Wyandotte, MI	Conventional	Table 5.8
Stony Island,	June 19 - July 11, 1930		Across the Stony Island Channel between Grosse Ile and Stony Island		Table 5.9
Limekiln Crossing &	June 5 - July 10, 1930		Across the Ballards Reef Channel from a cofferdam to the Canadian shore		Table 5.10
Dry Cut	May 26 - July 9, 1930		Across the Livingstone Channel, between the cofferdams, below Stony Island		Table 5.11

TABLE 5.1 Summary of Detroit River Discharge Measurements (cont'd)

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
Lower Detroit River: Trenton Channel, (See Subsection 5.5)	July 19 - Sept. 9, 1933	To evaluate the change in the distribution of flow resulting from the placement of the cofferdam constructed for the widening and deepening of the Livingstone Channel	1500 ft below the foot of Orange Street in Wyandotte, MI	Conventional	Table 5.12
Limekiln Crossing,	Aug. 9 - 15, 1933		Across the Ballards Reef Channel, from an old cofferdam to the Canadian shore		Table 5.13
Stony Island,	Aug. 24 & 25, 1933		Across the Stony Island Channel, between Grosse Ile and Stony Island		Table 5.14
Amherstburg,	Aug. 16 - Sept. 5, 1933		Across Amherstburg Channel, extending from the Canadian mainland near Amherstburg, Ontario, to Bois Blanc Island		Table 5.15
Sugar Island &	Aug. 22 & 23, 1933		From Sugar Island to Hickory Island		Table 5.16
North Bois Blanc	Aug. 26 - Sept. 1, 1933		Southeast corner of the upper cofferdam to the north end of Bois Blanc Island		Table 5.17
Fighting Island & (See Subsection 5.6)	July 20, 1934	To measure the distribution of flow east of Fighting Island	Across the Fighting Island Channel, above Grass Island	Floats	Not Recovered
Grass Island			From Grass Island to the Canadian mainland at LaSalle, Ontario		

TABLE 5.1 Summary of Detroit River Discharge Measurements (cont'd)

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
Belle Isle & (See Subsection 5.7)	Sept. 17 - 23, 1937	To assess the distribution of flow in the upper and lower Detroit River, since the widening and deepening of the river for navigation	900 ft below the head of Belle Isle, across the American Channel	Conventional	Table 5.18
Lower Detroit River: Stony Island,	Aug. 6 - 10, 1937		Across the Stony Island Channel between Grosse Ile and Stony Island		Table 5.19
Dry Cut,	Aug. 11 - 17, 1937		Across the Livingstone Channel, between the dikes, below Stony Island		Table 5.20
Limekiln Crossing,	July 29 - Aug. 4, 1937		Across the Ballards Reef Channel, from near the northern end of the Livingstone Channel dike to the Canadian shore		Table 5.21
Trenton Channel,	July 22 - 27, 1937		1500 ft below the foot of Orange Street in Wyandotte, MI		Table 5.22
Sugar Island,	Aug. 18 - 21, 1937		From Sugar Island to Hickory Island		Table 5.23
Sugar Island Dike,	Sept. 3 & 4, 1937		From Sugar Island to the Sugar Island dike, which extends west from the Livingstone Channel dike		Table 5.24
Lower Cut,	Aug. 23 - 25, 1937		Between the dikes of the Livingstone Channel, adjacent to Bois Blanc Island		Table 5.25
Bois Blanc Dike &	Sept. 8 & 9, 1937		Extended E/W from Bois Blanc Island to the Livingstone Channel dike; about 980 ft north of the Lower Cut Section		Table 5.26
Amherstburg Channel	Aug. 27 - Sept. 2, 1937		Across Amherstburg Channel, extending from the Canadian mainland near Amherstburg, Ontario, to Bois Blanc Island		Table 5.27

TABLE 5.1 Summary of Detroit River Discharge Measurements (cont'd)

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
Trenton Channel (See Subsection 5.8)	May 17 - 23, 1941	To determine the effect on flow of channel dredging done in 1940	1500 ft below the foot of Orange Street in Wyandotte, MI	Conventional	Table 5.28
Lower Detroit River: Trenton Channel, (See Subsection 5.9)	Aug. 5 - 8, 1944	To acquire additional hydraulic data for use in establishing equations of flow and in dealing with problems related to the effects of changes in the regimen of the river	1400 ft below the foot of Orange Street in Wyandotte, MI	Conventional	Table 5.29
Limekiln Crossing,	Aug. 15 - 18, 1944		2 miles north of Amherstburg, Ontario, 60 ft south of the Limekiln Crossing Rear Range Light		Table 5.30
Amherstburg Channel,	Aug. 22 - 24, 1944		Adjacent to the Mullen Coal Co. dock, north of Richmond Street in Amherstburg, Ontario		Table 5.31
Boblo Dike (Bois Blanc Dike),	Sept. 4 & 5, 1944		Between the west side of Bois Blanc Island and the east dike of the Livingstone Channel, 2000 ft below Light 20		Table 5.32
Dry Cut,	Sept. 2 - 5, 1944	No information recovered; file missing	In upper Livingstone Channel, between Lights 24 and 22		Table 5.33
Lower Cut,	Aug. 25 & 26, 1944		Across the lower Livingstone Channel, between the piers which supported Lights 17 and 18		Table 5.34
Sugar Island Dike &	Sept. 8 & 9, 1944		Between Sugar Island and the E/W dike running from the Livingstone Channel dike		Table 5.35
Sugar Island	Sept. 6 & 7, 1944		Between Sugar Island and Hickory Island		Table 5.36
Lower Detroit River: (See Subsection 5.10)	1960	No information recovered; file missing			

TABLE 5.1 Summary of Detroit River Discharge Measurements (cont'd)

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
Lower Detroit River: Trenton Channel, (See Subsection 5.11)	June 25 - 29, 1963 & Nov. 15 - 22, 1963	To determine the distribution of flow through the various channels of the lower Detroit River	1400 ft below the foot of Orange Street in Wyandotte, MI	Conventional	Table 5.37
East Celeron,	June 10 - 15, 1963		Between Grosse Ile Island and Celeron Island		Table 5.38
West Celeron,	June 12 - 15, 1963		Between Celeron Island and Horse Island		Table 5.39
Dry Cut,	May 3 - 11, 1963		In the upper Livingstone Channel, between Lights 22 and 24		Table 5.40
Lower Cut,	April 26 - May 15, 1963		Across the lower Livingstone Channel, between the piers which supported Lights 17 and 18		Table 5.41
Limekiln,	May 14 - 18, 1963		2 miles north of Amherstburg, Ontario, 60 ft south of the Limekiln Crossing Rear Range Light		Table 5.42
Hackett,	April 17 - 29, 1963		Across lower Amherstburg Channel, from Bois Blanc Island to the Canadian mainland		Table 5.43
Stony Island,	May 29 - June 1, 1963		Across the Stony Island Channel, between Grosse Ile and Stony Island		Table 5.44
Sugar Island,	May 23 - 27, 1963		Between Sugar Island and Hickory Island		Table 5.45
Sugar Island Dike,	May 25 - 28, 1963		Between Sugar Island and the E/W dike of the Livingstone Channel dike		Table 5.46

TABLE 5.1 Summary of Detroit River Discharge Measurements (cont'd)

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
Boblo Dike,	April 25 - May 7, 1963	See Previous Page	Between the west side of Bois Blanc Island and the east dike of the Livingstone Channel, 2000 ft below Light 20	See Previous Page	Table 5.47
LaSalle &	June 19 - 22, 1963		Between Fighting Island and LaSalle, Ontario		Table 5.48
West Grassy	June 27 - 29, 1963		Across upper Trenton Channel, west of Grassy Island		Table 5.49
Lower Detroit River: Limekiln, (See Subsection 5.12)	Aug. 15 - 31, 1966	To acquire data for the development of a mathematical model of the Detroit River	2 miles north of Amherstburg, Ontario, 60 ft south of the Limekiln Crossing Rear Range Light	Conventional	Table 5.50
Stony Island,	Aug. 19 - Sept. 1, 1966		Between Stony Island and Grosse Ile		Table 5.51
Dry Cut,	Aug. 15 - 31, 1966		In the upper Livingstone Channel, between Lights 24 and 22		Table 5.52
Lower Cut,	July 8 - Aug. 3, 1966		Across the lower Livingstone Channel, between the piers which support Lights 17 and 18		Table 5.53
Sugar Island Channel,	July 14 - Aug. 6, 1966		Between Sugar Island and Hickory Island		Table 5.54
Sugar Island Dike &	July 19 - Aug. 8, 1966		Between Sugar Island and the E/W dike running from the Livingstone Channel dike		Table 5.55
Hackett	July 9 - Aug. 2, 1966		Extended across lower Amherstburg Channel, from Bois Blanc Island to the Canadian mainland, about 300 ft upstream from the 1963 section		Table 5.56

TABLE 5.1 Summary of Detroit River Discharge Measurements (cont'd)

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
Lower Detroit River: (See Subsection 5.13)		No information recovered; file missing			
Amherstburg-Gap & (See Subsection 5.14)	Sept. 7 - 13, 1973	To augment available data regarding flow in the Detroit River, especially for periods of high water levels	2500 ft northwest of Amherstburg, Ontario	Conventional	Table 5.57
Bois Blanc Dike	Sept. 8 - 13, 1973		3000 ft west of Amherstburg, Ontario, from west shore of Bois Blanc Island to east side of lower east Livingstone Channel dike		Table 5.58
Bar Point-Lee (See Subsection 5.15)	May 5 - Oct. 3, 1975	As part of waste water management studies	On the extreme lower end of the Detroit River, 2.5 miles south of Gibraltar, MI, at Maple Beach, extending east to Bar Point Summit Beach, Ontario	Conventional	Table 5.59
Trenton Channel (See Subsection 5.16)	Aug. 1 - 7, 1975	To obtain data to augment the math model of the Detroit River and various hydraulic studies	Property of Wyandotte Chemical Corp., Wyandotte, MI, across to a point about 0.6 mi south of upstream end of Hennepin Point	Conventional	Table 5.60
Belle Isle and Lower Detroit River: Belle Isle Harbor Master, (See Subsection 5.17)	June 10 - 13, 1980	To provide the necessary technical framework for the calibration of an on-going Math Modeling Program on the Detroit River	Between Belle Isle and the American shore, 500 ft below the Belle Isle Bridge	Conventional	Table 5.61
Belle Isle Main Channel,	June 10 - 13, 1980		Across the Fleming Channel, between Belle Isle and the Canadian shore		Table 5.62
LaSalle,	June 18 - 23, 1980		Between Fighting Island and LaSalle, Ontario		Table 5.63

TABLE 5.1 Summary of Detroit River Discharge Measurements (cont'd)

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
Upstream Fighting Island,	June 18 - 23, 1980	See Previous Page	Across Fighting Island Channel, between the U.S. mainland and Fighting Island	See Previous Page	Table 5.64
Wyandotte-Trenton Channel,	June 18 - 23, 1980		1500 ft below the foot of Orange Street, Wyandotte, MI, extended from the U.S. mainland to Grosse Isle		Table 5.65
Limekiln,	June 26 - July 1, 1980		2 miles north of Amherstburg, Ontario, 60 feet south of the Limekiln Crossing Rear Range Light		Table 5.66
Livingstone-Stony,	June 26 - July 1, 1980		Across the Livingstone Channel, between and near the top of the dikes		Table 5.67
Stony Island,	June 26 - July 1, 1980		Between Stony Island and Grosse Ile		Table 5.68
Bois Blanc Dike,	June 25 - July 1, 1980		3000 ft west of Amherstburg, Ontario, from west shore of Bois Blanc Island to east shore of lower east Livingstone Channel dike		Table 5.69
Downstream Livingstone,	June 25 - July 1, 1980		Between the dikes of the Livingstone Channel, adjacent to Bois Blanc Island		Table 5.70
Sugar Island Channel &	June 25 - July 1, 1980		Between Sugar Island and Hickory Island		Table 5.71
Sugar Island Dike	June 26 - July 1, 1980		Between Sugar Island and the E/W dike running from the Livingstone Channel dike		Table 5.72

TABLE 5.1 Summary of Detroit River Discharge Measurements (cont'd)

NAME OF SECTION	PERIOD	PURPOSE	LOCATION	MEASUREMENT TECHNIQUES	DISCHARGE MEASUREMENTS*
North Peach Island (See Subsection 5.18)	May 29, 1981	To provide the necessary technical framework for the calibration of an on-going Math Modeling Program on the Detroit River	Across the main channel, between Peach Island and the U.S. shore	Conventional	Table 5.73
Revere (See Subsection 5.19)	Aug. 20 - 24, 1984 Dec. 11 - 14, 1984 Nov. 8 - 9, 1988	To calibrate the electromagnetic current velocity meters	100 ft upstream of the Fort Wayne gauge	Conventional	Tables 5.74 - 5.76
Elizabeth Park, (See Subsection 5.20)	May 6 & 7 & Aug. 27, 1986	Requested by the U.S. Environmental Protection Agency	Across the Trenton Channel, from Elizabeth Park on the U.S. mainland to Grosse Ile	Conventional	Table 5.77
Wyandotte Chemical &	May 7 & Aug. 27, 1986		1500 ft below the foot of Orange Street, Wyandotte, MI, and extending from the U.S. mainland to Grosse Ile		Table 5.78
Monsanto Chemical	Aug. 26, 1986		6500 ft downstream of Elizabeth Park Section, from the U.S. mainland to Grosse Ile		Table 5.79
Fort Wayne (See Subsection 5.21)	1943-1986	To acquire additional hydraulic data for use in establishing equations to compute the flows in the Detroit River and other hydraulic studies, needed due to dredging	Near the foot of Livernois Avenue in Detroit, MI (adjacent to historic Fort Wayne)	Conventional	Table 5.80 - 5.100

*See Appendix C (under separate cover)